Energy Efficiency in the Federal Government

GOVERNMENT BY GOOD EXAMPLE?

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Foreword

This report was prepared in the course of the ongoing OTA assessment, "U.S. Energy Efficiency: Past Trends and Future Opportunities," which is being carried out in response to requests from the Senate Committees on Governmental Affairs and on Energy and Natural Resources; the House Committee on Energy and Commerce; and endorsed by the Subcommittee on Environment, Energy, and Natural Resources of the House Committee on Government Operations and by the chairman of the Subcommittee on Environment of the House Committee on Science, Space, and Technology. Other reports to be prepared in this assessment will examine energy use in the residential and commercial sector, industry, transportation, and electric and gas utilities.

This report focuses on the Federal Government, the Nation's largest single energy consumer, in terms of the opportunities and constraints for the use of energy efficient technologies. Energy efficient technologies could greatly reduce energy demand growth and spending in the United States and lessen environmental impacts while increasing productivity. Yet, in today's public and private markets, adoption rates for many of these technologies are low. This report reviews past and current efforts to improve Federal energy efficiency and discusses policy options that could accelerate the adoption of these measures by the Federal Government.

OTA appreciates the substantial assistance received from many organizations and individuals in the course of this study. Members of the advisory panel provided helpful guidance and advice; reviewers of the draft report contributed greatly to its accuracy and completeness; personnel at the case study facilities shared their valuable experiences and perspectives. To all of them goes the gratitude of OTA and the personal thanks of the project staff.

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NOTE: OTA appreciates and is grateful for the valuable assistance and thoughtful critiques provided by the advisory panel members. The panel does not, however, necessarily approve, disapprove, or endorse this report. OTA assumes full responsibility for the report and the accuracy of its contents.

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Chapter 1

Introduction and Summary

INTRODUCTION

The Federal Government is the Nation's largest single energy consumer. In fiscal year 1989, it spent $8.7 billion on energy in its own facilities and operations, and another $4 billion subsidizing the energy expenses of low-income households (see figure 1-1). The energy purchases paid for by the Federal Government were over 3 percent of the total Americans spent on energy in that year. Much of this energy is inefficiently used. For example, **it appears that commercially available, cost-effective measures including high efficiency lighting and carefully operated heating, ventilating, and air-conditioning (HVAC) systems could likely conserve at least 25 percent of the energy used in Federal buildings with no sacrifice to comfort or productivity.**

Improving energy efficiency has several benefits, both for the government and for the Nation as a whole. Inefficient use of energy needlessly exacerbates reliance on imports of oil from foreign sources, contributes to local and global environmental concerns such as smog and climate change, and consumes capital and operating expenditures which would be better invested elsewhere.

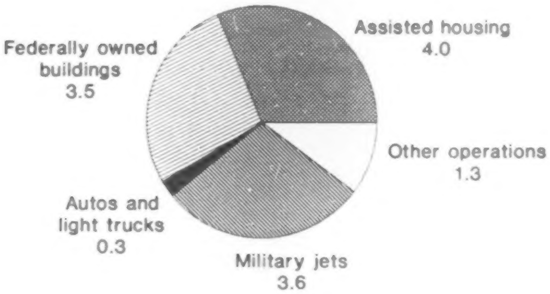
The Federal Government has an opportunity to set a good example for efficient energy use while reducing Federal spending, reliance on imported oil, and adverse environmental impacts. It has broad experience using electricity, natural gas, petroleum products, and other energy in housing, office buildings, hospitals, transport, and other facilities and operations. **From lighting to HVAC equipment to automobiles, Federal procurement could also expand market opportunities for producers of efficient technologies, demonstrate measures useful in the private sector, and encourage more research and development (R&D) by manufacturers.**

Since the mid-1970s, Congress and the executive branch have developed several programs to improve energy efficiency in Federal facilities and operations. According to the Department of Energy (DOE), between 1975 and 1989 these programs saved close to $7 billion (or about 5 percent of Federal energy spending), far more than the $2.5 billion invested in energy conservation measures. Despite this achievement, considerably greater savings still are possible. Many energy industry observers believe that efficient technologies could greatly reduce energy use in the United States and reduce environmental impacts while increasing productivity. Yet Federal agencies' use of many energy efficient measures is low. For example, inefficient, costly-to-operate lighting is still common throughout the millions of square feet of office space owned or leased by the Federal Government and its contractors.

The failure of Federal agencies to fully implement the use of energy efficient technologies results from a variety of factors. Overall, **energy efficiency is not central to most agencies' missions and has received a relatively low priority.** Reflecting the low priority, **there is a shortage of trained personnel and a scarcity of the capital needed to make even short-term investments.** Several other constraints seem important, as well. These include a lack of incentives, a lack of systematic assessment of opportunities, and uncertainty about the cost and performance of some technologies. Many of these factors apply to the private sector as well as to the Federal Government. An examination of energy efficiency measures and the technical and institutional impediments to their use is important in developing effective, low cost energy policies not only for the Federal Government but for the economy as a whole.

This report examines opportunities for improving the efficiency of Federal energy use and spending, concentrating on opportunities in federally owned buildings. Some opportunities for Federal vehicle fleets are also discussed. The report also briefly describes some specialized but large Federal energy uses such as military aircraft. Prospects for energy efficiency gains in federally assisted housing are also briefly discussed since the Federal Government spends several billion dollars each year on the energy used in those households. Although assisted housing is not the focus of this report, it is included to give a more complete picture of Federal spending on energy.

Figure 1-1—Federal Spending on Energy, Fiscal Year 1989



SOURCE: U.S. Department of Energy, Federal Energy Management Program, "Report on Federal Government Energy Management and Conservation Programs," October 1990.

Chapter 2 reviews the diverse policies and programs the Federal Government has pursued to improve its energy efficiency. Chapter 3 examines the technical and economic prospects for improving efficiency to reduce Federal spending on energy in buildings, including both federally owned buildings and federally assisted housing. Chapter 4 describes the energy used in general operations, including automobile fleets and military operations. Chapter 5 presents case studies of energy use and prospects for savings in six federally owned, leased, and assisted facilities. Chapter 6 describes the main constraints to improved energy efficiency in Federal facilities, including both technical and institutional impediments. Finally, chapter 7 suggests congressional policy options in light of the existing, untapped technical and economic opportunities for energy savings.

FEDERAL SPENDING ON ENERGY

Federal spending on energy can be categorized in four groups: 1) federally owned and leased buildings, 2) federally assisted housing, 3) Federal auto and truck fleets, and 4) specialized operations, predominantly military mobility. This section describes those categories and how energy is used in them. The Federal agencies with the largest energy use are noted at the end of the section.

Federally Owned and Leased Buildings

The Federal Government owns and leases around 500,000 buildings of various sizes, construction, and uses. About 51,000 of these are commercial buildings[1] owned by the government in the United States with between 1 and 2 billion square feet of floor space. Federal buildings are highly diverse, including offices, retail shops, hospitals, and industrial facilities. The Federal Government also owns 422,000 housing units for military families, and a far smaller number in the Departments of the Interior, Transportation, and other agencies. The government leases about 7 percent of its floor space from private owners.

The Department of Defense (DOD) owns about two-thirds of the Federal Government's total domestic floor space. Federal agencies own most of the building space they occupy, but also often lease some of their space either from private companies or from the General Services Administration (GSA), which owns and leases commercial space on their behalf. Because GSA manages some property for other agencies, it is the third largest owner (after DOD and the U.S. Postal Service (USPS)) of Federal buildings, with nearly 9 percent of the total government-owned building space.

In fiscal year 1989, the energy used in Federal buildings cost the U.S. Treasury around $3.5 billion.[2] Most of the energy is used just to make the buildings inhabitable, that is, to provide light and HVAC. Large amounts of additional energy are used to power the wide assortment of appliances and equipment used in the buildings, ranging from computers to conveyor belts to stoves.

Electricity is the dominant energy form used in Federal buildings in terms of total annual spending ($2.4 billion in 1989). Electricity is essential for powering lights, electronic equipment, and the wide array of motors found in everything from HVAC equipment to elevators to conveyor belts and is also used for heating and cooking. Lighting alone accounts for about 30 percent of electricity use in commercial buildings. While electricity is extremely versatile, it is also the most expensive per unit of energy delivered to the Federal Government (at an average $17/million Btu, electricity is about four times more costly than natural gas).

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[1] Defined as "roofed and walled structures used predominantly for a nonresidential, nonagricultural, and nonindustrial purposes" with floor space over 1,000 square feet, as in U.S. Department of Energy, Energy Information Administration, *Characteristics of Commercial Buildings 1986*, DOE/EIA-0246(86) (Washington, DC: U.S. Government Printing Office, September 1988), p. 3.

[2] An additional unestimated amount was spent on energy used in leased buildings for which the Federal Government does not pay utilities directly.

Natural gas is the second most heavily used fuel, accounting for about $0.5 billion in 1989. It provides most of the energy for space heating, water heating, and cooking. Fuel oil is also used for heating and accounted for about $0.35 billion in 1989. Other energy forms include coal and purchased steam.

Federally Assisted Households

As of 1989 there were over 90 million households for about 240 million people in the United States.[3] The Federal Government subsidizes part or all of the utility bills in about 9 million of these households. Two executive agencies are responsible for the vast majority of indirect Federal expenditures on residential energy use: the Departments of Housing and Urban Development (HUD) and Health and Human Services (HHS).[4] These two agencies subsidize or provide assistance payments for residential utility bills for low income Americans.

Each year, HUD spends from $2 to $3 billion subsidizing the energy bills for 3.6 million federally assisted housing units. There are two main HUD-assisted housing programs: a low-income public housing program and the Section 8 rental housing assistance program which can be used in privately owned housing. Both programs are administered by HUD-regulated local public housing authorities (PHAs), of which there are about 2,700 nationwide.

HHS's Low Income Home Energy Assistance Program (LIHEAP) assists about 6 million low-income households in meeting the costs of residential heating or cooling. Some LIHEAP recipients live in HUD-assisted housing, but the majority do not. HHS provides grants to the States, Indian tribes, and territories which administer the program. In fiscal year 1989, HHS spending on LIHEAP totaled $1.4 billion.

A few main energy uses constitute the majority of residential energy consumption and spending. By far the highest on the list both in terms of total energy use and spending is space heating. Natural gas supplies over two-thirds of the energy used for space heating. Most households also have a water heater, which on average consumes 18 million Btus/year, making that the next largest residential energy use. As with space heating, natural gas provides two-thirds of the energy used in water heaters.

Refrigerators are the largest single use of residential electricity, consuming about 20 percent of the total. Nearly every household has a refrigerator, which on average consumes about 1,500 kWh/year.[5] Air conditioning is the second largest residential electricity use after refrigerators. A large list of other uses including cooking, dishwashers, clothes washing and drying, lighting, and electronic equipment such as televisions make up the remaining 16 percent of household energy.

Federal Auto and Truck Fleets

In total the Federal Government owned 106,108 sedans, 15,973 station wagons, and 323,479 light trucks in 1988. In addition, there were 12,641 buses and ambulances and 55,481 medium and heavy trucks. DOD and USPS have the largest fleets, each with about 30 percent of the total. GSA, which has oversight responsibility over federally owned and leased passenger vehicles, has about 20 percent of the total. Almost every Federal agency owns at least one vehicle and may lease many others from the GSA Federal Fleet Management System. With few exceptions, the Federal automotive fleet is petroleum-fueled (i.e., gasoline and diesel fuel), although there are some alternate fuel vehicles (e.g., natural gas). Each year, the Federal Government replaces about 100,000 of its cars and light trucks, accounting for about 1 percent of domestic production. About 50,000 of these are procured by GSA.

Increasingly, the Federal auto fleet is relying on compacts. In 1988 compacts outnumbered other classes of sedans by almost 2:1. The shift in the makeup of the Federal fleet to smaller, more fuel efficient cars has resulted in higher fleet average fuel mileage. In 1989, the Federal Government bought 329 million gallons of gasoline at a cost of $309 million. In 1989, the average Environmental Protection Agency (EPA) fuel economy rating of the Federal automobile fleet was 29.4 miles per gallon (mpg), 7 percent higher than the minimum corporate

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[3] This population estimate does not include the homeless and people living in institutions (e.g., military barracks and prisons).

[4] As noted previously, the Department of Defense owns about 400,000 military housing units.

[5] Refrigerators in federally owned or assisted housing may be smaller with less energy-using features (e.g., through-the-door ice dispensers) than the average.

Photo credit: General Dynamics

Military aircraft consumed over 3.6 billion dollars' worth of jet fuel in fiscal year 1989.

average fuel economy requirement for manufacturers.

Other Operations

In fiscal year 1989, the Federal Government consumed about $4.9 billion worth of energy in highly specialized operations. By far most of the energy used in operations is defense-related in the form of military mobility energy. Military mobility refers to activities such as flying aircraft, sailing naval vessels, and operating tanks and other land-based military equipment. In fiscal year 1989, military aircraft and surface equipment consumed over $3.6 billion in jet fuel and about $0.6 billion in diesel fuel.

Much of the remaining energy for operations is also defense-related, used by DOD in various processes and by DOE in its uranium enrichment facilities and production nuclear reactors. Production reactors are industrial facilities for producing nuclear fuel and nuclear weapons materials. Nondefense operations using large amounts of energy include DOE's research facilities such as reactors and linear accelerators.

Federal Agencies With the Largest Energy Use

The five Federal agencies using the most energy in their facilities and operations are, in order: DOD, DOE, USPS, the Department of Veterans Affairs, and GSA. Together they consume over 90 percent of the Federal Government's total.

DOD is by far the largest consumer of energy in the Federal Government. In fiscal year 1989, DOD consumed over 80 percent of the energy used in the Federal Government (see figure 1-2). DOD used nearly 1.6 quadrillion Btus costing more than $2 billion in its 1,896 million square feet of buildings. DOD's facilities are extremely diverse, including residences, offices, and food service and health care facilities. DOD also spent about $4.6 billion on energy for general operations, the majority for military mobility.

The largest consumer of energy among the civilian agencies is DOE. Energy-intensive processes such as nuclear research and development and production of nuclear materials accounted for nearly 40 percent of DOE's energy use. The USPS, with its vast number of post offices and delivery operations is the next largest Federal consumer. Veterans Affairs ranks next with its 174 medical centers. Rounding out the five largest agencies is the GSA, in its role as provider of some of the office space used by other agencies.

In addition to the $8.7 billion spent by Federal agencies in their own facilities and operations, HUD spent about $2.5 billion subsidizing utility expenses in HUD-assisted housing, and HHS spent about $1.4 billion on energy assistance for low-income households.

PROSPECTS FOR ENERGY- AND COST-SAVINGS

After many years of both R&D and commercial use throughout the private sector and within the Federal Government, it is clear that energy efficient technologies can work well and reduce costs. Federal agencies estimate that between 1975 and 1989, their energy efficiency programs for Federal facilities and operations saved $7 billion, or about 5 percent of the $128 billion spent on energy during that time.[6] Savings from many of these programs continue to accrue.

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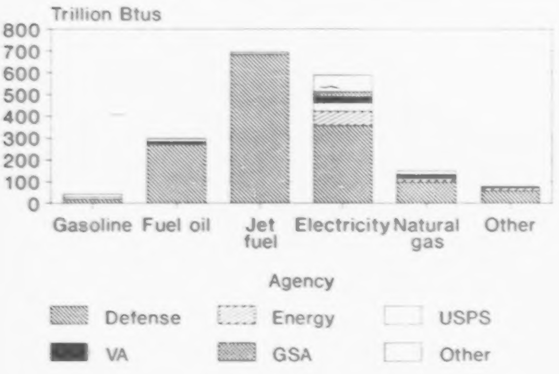
[6] Estimates for 1975-84 from the U.S. Department of Energy, "Annual Report on Federal Government Energy Management Fiscal Year 1985," DOE/CE-0171, August 1986, table C, p. C-1. Estimates for 1985-89 from the U.S. Department of Energy, "Annual Report to Congress on Government Energy Management and Conservation Programs, Fiscal Year 1989," Oct. 3, 1990, table E, p. 74.

Figure 1-2—Energy Consumption by Agency Facilities and Operations, Fiscal Year 1989



SOURCE: U.S. Department of Energy, Energy Information Agency, "Annual Energy Review 1989," DOE/EIA-0384(89), May 1990.

Considerable additional savings appear possible, although Federal agencies have not developed estimates of the potential energy- and cost-savings or of the capital and other resources required to attain those savings. The best information available (which is only very approximate) indicates that a reduction in energy use of *at least* an additional 25 percent is technically feasible and economically attractive for both federally owned and federally assisted buildings. That represents an annual savings of nearly $900 million in federally owned buildings, although achieving those savings could require initial investments on the order of $2 to $3 billion. Additional cost-effective savings would be possible with further investments, although any precise estimates are more speculative.

Performance of Energy- and Cost-Saving Measures

There are no magic technologies which will revolutionize Federal energy use (or private-sector energy use). Rather, there are many diverse technologies which work well that together can substantially reduce energy use and spending. For nearly every application of energy, measures are available that can improve the efficiency of use. Many have attractive cost and performance characteristics. Some energy- and cost-saving measures, such as motion detectors to control lights in occasionally used spaces, and highly efficient electronic ballasts and fluorescent T-8 tubes, have commercially proven economic and operating performance. Eventually, use of these approaches may become the standard rather than the exception that they currently are.

Not all energy efficiency programs have performed as well as expected.[7] **Sometimes new technology does not perform as it should,** as in the case of the excessive premature failure rate which plagued some early electronic ballasts. As a corollary, technologies are continually being improved and refined, or they will disappear from the market. The demonstrated high reliability of currently available electronic ballasts again provides a good example. Unfortunately, as with any evolving technology (and as with many well-established technologies), some products have marginal to poor performance and economics but have yet to be driven off the market.

Because of the wide variety of buildings, uses, technologies and other conditions, it is possible that good technologies can be misapplied, resulting in poor performance or unmet economic expectations. For example, because compact fluorescent lamps are larger and heavier than the incandescent bulbs they replace, there are many light fixtures in which they cannot be used. Thus, a program to replace all incandescent bulbs in a building with compact fluorescents could produce considerable dissatisfaction.

Deciding which measures to pursue often requires careful engineering and economic analyses. Successful programs, those which reduce energy use and overall costs, also often require ongoing, dedicated efforts to ensure that they work initially and continue to work. **Some measures have highly site-specific economic and performance characteristics, requiring fairly detailed engineering and economic analyses.** For example, the benefits of adding an energy monitoring and control system in a facility depend on the type of HVAC equipment in place and possible plans to replace existing equipment, as well as the buildings' external characteristics and internal layout and occupancy. Similarly, opportunities to delamp, or reduce lighting in over lit areas, can only be determined from a properly conducted site survey which evaluates current lighting levels and the levels which would result after delamping. Another factor causing the benefits of efficiency measures to be site-specific is that energy prices vary considerably across the country. For example, the average price of electricity for commercial customers in 1989 ranged from a high of $0.099/kWh in the State of New York to a low of $0.041/kWh in the State of Washington.[8] While the applicability of many measures is site-specific, agencies often conduct site surveys including engineering and economic analyses to identify candidate measures, although inadequate funding and staffing have constrained full implementation.

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[7] In this report, "energy efficiency program" refers to a combination of energy efficient technology and an institutional system to select and implement that technology.

Savings Prospects in Federally Owned Buildings

There is little question that a large fraction of the Federal Government's $3.5 billion direct annual spending on energy in its own buildings could be greatly reduced using existing, proven technologies. For example, **at the four federally owned facilities in OTA's case studies, the facility personnel estimated that an average savings of at least 25 percent in annual operating cost and energy use appears achievable with proven and highly cost-effective technology.** This saving requires no change in occupant comfort or productivity; rather, it involves more effective use of energy, either through more efficient equipment or through improved operations and maintenance practices. OTA's case study estimates were intended to include only highly cost-effective options in which the capital costs and other costs of implementation are small compared to the savings, with simple paybacks of under 3 years. Some measures such as improved operation and maintenance or using high-efficiency lighting systems supported by utility rebates have paybacks of under 1 year. A less stringent economic test which is more consistent with the cost of capital to government would produce considerably higher estimates of savings potential (see box 1-A).

The Federal Government has not developed estimates of either the governmentwide potential for energy and cost savings or of the capital and other resources required to attain those savings. Similarly, none of the individual Federal agencies contacted by OTA have produced such estimates for their own facilities and operations although some are undertaking such efforts. All cite difficulties of performing the information collection and analyses required even for approximate estimates. Although building audits mandated under the Energy Conservation Policy Act were conducted at most major facilities a decade ago, there has been no Federal effort to compile the results, much less to keep results current. The same appears to be true of the facility energy surveys mandated under the Federal Energy Management Improvement Act of 1988.

The lack of reasonably detailed, comprehensive analytical effort to date should not be interpreted as representing a lack of energy efficiency opportunities. Although Federal agencies have not published overall estimates of prospects for efficiency gains, they often take the public position that large gains are possible. It is important to note that **many relatively easy, low risk energy- and cost-saving measures with excellent economic characteristics have yet to be implemented at Federal facilities.** These measures range from using higher efficiency lights and equipment to improved operation and maintenance of HVAC systems. The best options currently available appear to be attractive under virtually any set of reasonable assumptions of future energy prices.

Savings Prospects in Federally Assisted Households

As with the Federal Government's commercial buildings, **there seems little question that increased use of existing, proven technologies would reduce a large fraction of the $4 billion spent on residential energy by the government in federally assisted housing.** This savings requires no loss of occupant comfort and frequently actually increases comfort, as in the case of repairing broken windows and stopping drafts. Since space heating is the leading residential energy use, many opportunities for energy and cost savings depend on promoting higher efficiency heating equipment and weatherization programs. Opportunities for savings are large. For example, a comprehensive study for HUD of energy-saving opportunities in public housing published in 1988 estimated the potential for over 30 percent savings with an average payback of 4.5 years using measures such as weatherstripping and insulation and door and window repairs. Similarly, facility managers at OTA's case study of one public housing

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[8] U.S. Department of Energy, Energy Information Administration, *Electric Power Annual 1989* (Washington, DC: U.S. Government Printing Office, January 1991), table 30, p. 59.

Box 1-A—Annual Returns on Investment of 4 to 40 Percent: How High Is Highly Economic?[1]

Consider a project to replace a Federal building's fluorescent lamps and ballasts with well-proven high efficiency components. Is this project economically attractive if it costs $100,000 initially, has a 15-year life and saves $40,000 annually? What if it saves $12,000 annually? The answers depend on the Federal Government's investment criteria.[2]

The discount rate, or minimum annual return on investment, is the key investment criteria considered in economic analysis of investment options. The discount rate reflects the natural preference to have money sooner rather than later, and the cost of obtaining funds for investment. Under current law, the discount rate to be used in Federal energy analyses is set by the Secretary of Energy.[3] As specified by DOE, the discount rate is now based on the interest rate on U.S. Treasury bonds after removing the effects of inflation, subject to a floor of 3 percent and a ceiling of 10 percent.[4] Currently, 30-year Treasury bonds have a nominal yield of about 8 percent, which translates to 4 percent after inflation. Treasury notes and Treasury bills, which have shorter terms of under 3 years, currently have even lower yields, as low as 2 percent after inflation.

Because so many energy efficiency opportunities in the Federal Government are currently untapped and because there are severe data and analytical limits on existing governmentwide opportunities, this study focuses on measures with much higher returns on investment, typically 30 percent or more. (A project with a 3-year simple payback and a 10-year life has a return on investment of about 30 percent.) These investments are very highly economic, exceeding by several times the Treasury's cost of borrowed funds. They are also far higher than the average rate of return on electric utility investments (under 14 percent nominally in 1991). A lower rate more consistent with cost of funds would result in higher estimates of savings potential. Although this study focuses on highly attractive economic measures, it does not intend to suggest that a high discount rate is appropriate in analyzing Federal energy efficiency opportunities.

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[1] For an in-depth discussion of the practical aspects of economic analysis of energy investments, see U.S. Department of Commerce, National Bureau of Standards (now called the National Institute of Standards and Technology), *Comprehensive Guide for Least-Cost Energy Decisions*, NBS Special Publication 709 (Washington, DC: U.S. Government Printing Office, 1987).

Also, for a handbook tailored for use by Federal agencies, see U.S. Department of Commerce, National Bureau of Standards, *Life-Cycle Costing Manual for the Federal Energy Management Program*, NBS Handbook 135 (Rev. 1987) (Washington, DC: U.S. Government Printing Office, 1987).

[2] For the lighting retrofit example saving $40,000 annually, the project is economically attractive whether the discount rate is 3 percent or 10 percent. But if it saves $12,000 annually, it is attractive only if the discount rate is below about 8.4 percent.

[3] Federal Energy Management Improvement Act, 1988, Public Law 100-615.

[4] 10 CFR 436, as revised November 1990.

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authority estimated that cost-effective savings of at least 30 percent could be realized.

Studies of weatherization programs in both public housing and other low-income housing (i.e., those funded by HHS and DOE) have found considerable savings potential, although results are variable. To gain a better understanding of the potential gains and best methods to use, DOE's Weatherization Assistance Program recently began a comprehensive 3-year, $5-million review of performance. This analysis should help identify the economically and technically most effective programs for the future.

Energy- and cost-saving opportunities for appliances exist in all types of federally owned and assisted housing as well. For example, a simple program of using the most efficient and economic new refrigerators available, perhaps coupled with early refrigerator retirement, offers the prospect of reducing electricity used in federally assisted residences by a few percent. It would also encourage and support private sector development and commercialization of new, more efficient refrigerators. Such an early retirement program for other appliances such as water heaters and air conditioners could also save both gas and electricity cost-effectively. Of course, energy efficiency and cost are only two of several attributes (e.g., durability, features, operating performance) to consider when selecting any appliance or equipment.

Savings Prospects in Passenger Vehicle and Truck Fleets

As in the case with the Federal Government's owned and leased facilities, further efficiency gains appear possible. For example, for 1991 GSA's Automotive Commodity Center has contracted to purchase 13,000 passenger sedans with EPA-estimated mileage of 26 combined, all with automatic transmission.[9] There are other vehicles in the class that have better mileage ratings, including four domestically produced models which get 27 mpg with an automatic transmission. The manual transmission versions get 28 mpg. However, performance, first cost, and resale value all differ, complicating any assessment. Other, more novel efforts such as increasing the Federal Government's teleconferencing capabilities appear to have both energy and nonenergy benefits in reducing some types of travel.

Several experimental programs with alternative fuels and vehicle designs are underway in Federal agencies. For example, the Interagency Fleet Management System currently operates 25 methanol flexible-fuel sedans, with 40 more to be placed into service in the near future. Also, a procurement for light trucks fueled by compressed natural gas is under way.

Savings Prospects in Other Operations

Because of the highly specialized nature of other operations energy use (primarily military mobility), examination of opportunities for energy and cost savings there are largely beyond the scope of this report. However, there are energy-saving activities and opportunities even in military mobility, although not performed primarily to save energy. For example, there are many flight simulators in use by the Department of Defense. They supplement actual flying time to allow for improved pilot training with greater safety and lower cost. Part of the cost savings results from greatly reduced fuel consumption (e.g., fighter aircraft may consume more than 1,000 gallons of jet fuel each hour). Similarly, there are simulators for surface vehicles such as tanks. Although the use of simulators increases electrical load, this is far more than offset by the reduction in petroleum consumption.

CONSTRAINTS TO IMPROVED FEDERAL ENERGY EFFICIENCY

How is it possible that large energy- and cost-saving opportunities remain untapped by the Federal Government? There is no single, simple explanation. However, there are several constraints to more effective energy efficiency efforts, some major and some minor.

Table 1-1—Constraints on Improved Federal Energy Efficiency

Resource constraints

- Priorities favor other agency needs
  - Energy efficiency is not central to most agencies' missions
  - Energy is a small component of most agencies' expenditures
  - Little senior management interest
- Many measures require initial capital spending
- Many measures require personnel
  - Many facilities have no energy coordinator

Information constraints

- Opportunities have not been systematically assessed
- Agencies are uncertain of technical and economic performance
  - Does this technology really work?
  - Would the facility be better off waiting for next year's model?
  - Lack of metered energy-use data
  - Too little information sharing between agencies
- Energy-use decisions are dispersed, made by thousands of individuals
  - Implementation requires coordinated effort from diverse parties
  - Too little training and education for diverse parties

Lack of incentives

- Dollar savings often do not accrue to energy savers
  - Energy costs are readily passed through budgets
- Federal procurement policies often favor status quo
  - Procurement practices are complex, often restrictive

SOURCE: Office of Technology Assessment, 1991.

Constraints to improved Federal energy efficiency can be grouped as either: 1) funding and personnel limitations largely reflecting energy efficiency's relatively low priority, 2) a lack of information about the available opportunities, or 3) incentives which do not encourage efficient energy management (see table 1-1).

It is important to note that despite the constraints, there are many examples of highly motivated Federal employees who find ways to save energy and money for the government, and take advantage of whatever energy efficiency opportunities they can. Winners of the annual Federal Energy Efficiency Awards presented by DOE's Federal Energy Management Program are good examples. **The best practices found in Federal facilities demonstrate that, although there are constraints to improving Federal energy efficiency, none are fundamental obstacles which cannot be overcome.**

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[9] This represents only a portion of the automobiles to be purchased in 1991. Also, note that the Corporate Average Fuel Economy requirement is 27.5 mpg.

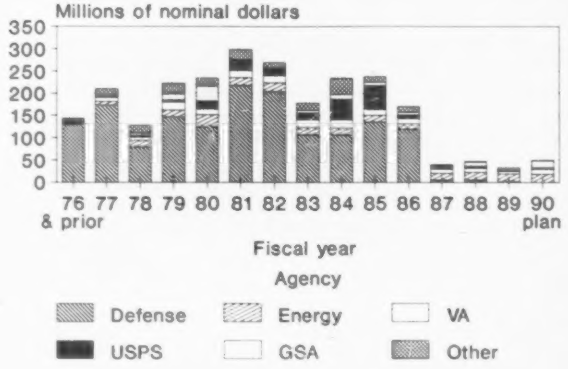
Resource Constraints

Adequate, stable funding is a common constraint to improved Federal energy efficiency. Many energy- and cost-saving projects such as replacing lamps and fixtures require a commitment of funding, including annual operating and maintenance costs or initial capital costs, or both. However funding for energy efficiency investment is often in short supply not only in the Federal Government, but in the private sector as well. Many energy efficiency projects have rapid paybacks of 3 years or less, representing a return on investment far higher than the Treasury's cost of funds. Despite these opportunities, Federal agencies have not sought and have not received a stable source of funding for even their most productive energy efficiency projects over the years, reflecting the low priority placed on energy efficiency. For example, the total capital budget earmarked specifically for energy efficiency projects in federally owned facilities dropped from a high of $297 million in 1981 to under $50 million in 1990, a decline of over 80 percent in nominal dollars (see figure 1-3).[10] Adjusted for inflation, the decline in conservation investments between 1981 and 1990 has been nearly 90 percent. That trend has begun to reverse, with GSA and DOD alone increasing their energy efficiency investments from under $7 million in fiscal year 1989 to $40 million in fiscal year 1991.

There are two main private sector supplements to direct Federal funding. Participation in utility rebate programs is one source of private sector funding which the Federal Government has recently begun exploring. In these programs, utilities encourage their customers to use more efficient devices or operating strategies, which can help the utility avoid the cost of building new powerplants. Utility programs may provide engineering expertise as well as funding. Prospects for increasing Federal participation in utility efficiency programs are excellent, with both utilities and the government benefiting.

Another private sector funding source is shared energy savings (SES) contracting, which has been promoted in the Federal Government since 1986. Under SES contracts, private companies use their own capital and personnel to perform energy efficiency improvements. Their services may include energy audits, purchase and installation of new equipment, efficient operation and maintenance of equipment, and training of personnel. In exchange, the contractors receive a specified portion of the cost savings for a number of years. This system provides agencies a private-sector alternative to Federal funding and staffing for energy efficiency investments, although by sharing the savings, it reduces the government's total cost-saving potential (since those savings are shared).

Figure 1-3—Direct Federal Energy Efficiency Funding, Fiscal Years 1976-90



SOURCE: U.S. Department of Energy, Federal Energy Management Program, "Annual Report to Congress on Federal Government Energy Management and Conservation Programs," fiscal years 1981-89; and "Federal Ten-Year Building Plan," DOE-CE-0047, September 1983.

Only four SES projects had been implemented by the end of 1990, representing a small fraction of the thousands of major Federal facilities. Federal agencies are becoming increasingly familiar with the SES approach and the program has been revised to provide expanded incentives for military facilities, but some implementation questions remain. Among them are whether current incentives are adequate to encourage greater use, and whether the contracts can be sufficiently simplified despite the need for terms such as the design of payment provisions tied to projected or actual energy savings and energy prices.

In addition to capital investment and at least as important, **most energy- and cost-saving projects require a commitment of well-trained personnel.** Personnel familiar with energy efficiency opportunities are needed at all levels, from the operations crews at a facility to the decisionmaking management of the agency. As in the case of funding, qualified personnel are typically in short supply, reflecting the low priority placed on improving energy efficiency. Among the most important personnel for identifying, implementing, and following through on energy efficiency measures are energy coordinators at individual facilities or in regional offices. However, many Federal facilities have no explicit, trained energy coordinator. Energy efficiency projects, to the extent they are developed, are pursued in the spare time of facility staff. Typically, this staff is charged with other critical missions, such as maintaining and operating existing equipment. Often, they have many additional projects which they could pursue depending on priorities, ranging from addressing environmental and safety hazards such as transformers laden with PCBs and asbestos floor tiles to planning for new facilities.

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[10] Note that some energy efficiency projects may be combined with major maintenance, so total efficiency spending is higher than this indicates. For example, when a roof needs repair, adding insulation is often part of the project, although the project is not labeled as an energy efficiency effort. Similarly, when a boiler fails and is replaced, use of a higher efficiency unit may be considered normal maintenance and not an efficiency investment.

Information Constraints

One obvious information constraint is **the lack of coordinated, comprehensive estimates of both the potential energy and cost savings and the capital and other resources required to attain those savings in federally owned facilities and operations.** Information about potential savings and costs is basic both for determining whether additional energy efficiency efforts are worthwhile and if so, for program planning and budgeting. The absence of basic, governmentwide information of this type appears to be a serious shortcoming in current Federal energy management efforts.

In contrast to the lack of information for federally owned facilities, HUD has produced estimates of the potential energy and cost savings as well as the investment required in HUD-assisted housing. HUD's studies provide a basis for internal HUD planning as well as congressional budget requests.

Uncertainty about the economic and technical performance of some energy efficiency technologies constitutes another information constraint. Does this technology really work? Would the facility be better off waiting for next year's model, which may have fewer bugs, cost less, and perform better? Since many energy efficiency measures are relatively new and not industry standard practice, these are eminently reasonable questions. Furthermore, the lack of detailed, metered data on energy use in Federal facilities complicates analysis of prospective measures and monitoring results of implemented measures. For example, some military bases may have only a few meters monitoring the energy use of thousands of buildings.

Photo credit: Pacific Northwest Laboratory

Mobile energy laboratories provide expertise and equipment to assist energy efficiency efforts at Federal facilities.

Uncertainty is at least partly in the mind of the user and can often be reduced through training and information sharing. Even well-demonstrated measures such as lights linked to occupancy sensors may be unfamiliar to a facility manager. Using any technology besides that which is already in place can entail some risk since no facility engineer wants complaints of inadequate lighting, or of buildings too hot in summer and too cold in winter. Nor do facility staff want to spend money and time unnecessarily on unproductive measures. Despite the wealth of diverse experiences with energy management techniques in Federal facilities, much more remains to be done to share the knowledge gained in those experiences.

The Federal procurement system often does not help reduce uncertainty. For example, for many commonly used items available through the Federal Supply System, there is little information comparing their life-cycle energy and economic characteristics. Similarly, facility engineers are given little information about the performance of light bulbs, which are supplied by DOD's Defense Logistics Agency. In contrast, GSA's Household Appliances Schedule, which includes products such as refrigerators, water heaters, and room air conditioners, lists items identified as having the lowest life-cycle cost. Often, the only information on product performance is that provided by the vendors. A purchaser must be aware of the opportunities for energy savings, and be willing to dedicate time and effort to learning about the alternative products. In absence of awareness, time, and effort, purchasers may be expected to continue to use standard replacement products rather than new energy efficient equipment.

The large number and diversity of parties involved in energy-use decisions exacerbates information constraints two ways. First, for many energy efficiency projects, the activities of the diverse parties need to be carefully coordinated to ensure that project conception, design, budgeting, and implementation all take place. That involves a considerable flow of information about engineering, economics, funding, and staffing between a wide range of agency personnel. Second, education and training about the opportunities and performance of energy-efficiency measures must be diverse, reflecting the diverse information needs and perspectives. Developing appropriate education and training programs requires considerable effort. For example, boiler operators and mechanics need to be aware of the importance of maintenance programs, as well as the specific mechanical steps required for their boilers. Facility managers and agency management, on the other hand, do not need to know how boilers and other equipment work. However, to make appropriate manpower and budgeting decisions, they need to be aware of the importance of energy-related maintenance programs in minimizing operating costs of a facility.

Lack of Incentives

Neither rewards nor penalties have been widely and systematically used in the Federal Government to encourage energy efficiency. There are notable exceptions (e.g., GSA's bonuses for facility personnel), but generally, facility managers have neither rewarded nor penalized staffs; regional and headquarters offices neither rewarded nor penalized facilities; and Congress neither rewarded nor penalized agencies. The lack of incentives contributes to the low priority placed on energy efficiency. Recently enacted incentives for DOD facilities should greatly reduce this constraint, if properly implemented.

The complexity of the Federal Government's procurement system creates some disincentives to use of new energy- and cost-saving measures. Federal procurement is naturally complex, reflecting the diverse goals of the process. While the foremost goals are "economy, efficiency and effectiveness," also included are socioeconomic development (e.g., for small, disadvantaged businesses), and efforts to promote competition and to protect against fraud and abuse. Together with the diversity of products and services noted above, the result is a complex system. Difficulties of identifying and then justifying the use of novel energy-efficient products and services can be a built-in disincentive to change.

POLICIES FOR FEDERAL ENERGY EFFICIENCY

Since the 1970s, both the executive branch and Congress have worked to promote energy efficiency within Federal agencies. Each new piece of legislation or program has combined past experience with new approaches in an effort to promote further efficiency gains in Federal agencies. Executive Order 12759, signed on April 17, 1991, is the most recent example of the ongoing Federal effort. Despite the array of programs developed over the past 15 years, the Federal Government still has many cost-effective opportunities to improve energy efficiency in its facilities and operations.

There are good reasons for Congress' continuing interest in Federal energy efficiency. The potential benefits include:

1. promoting use of energy efficient measures throughout the economy by demonstrating their cost and performance;
2. accelerating manufacturers' development of energy efficient technologies, again for use throughout the economy not just in the Federal Government;
3. learning first-hand which approaches work as a basis for national policy (e.g., while the Federal government is not entirely analogous to the private sector, many of the constraints on Federal energy efficiency and their solutions pertain to the private sector);
4. reducing Federal spending without reducing services; and
5. reducing energy-related environmental and security problems.

However, while the benefits of improved Federal energy efficiency can be great, there are costs as well. The effort involved can be considerable, requiring initial capital investment, allocation of staff, and the attention of Congress and senior executive branch personnel.

Options for Improving Federal Efficiency

Just as there is no single constraint explaining the failure to harness many opportunities, there is no single, simple policy that will ensure greater energy efficiency in the Federal Government. Fortunately, none of the constraints pose fundamental obstacles; rather, all can be addressed by a variety of initiatives. Some new initiatives involve simply making widespread use of the best practices found in individual facilities today.

Table 1-2 lists several options Congress could consider for Federal energy management. The default option, **maintaining the status quo**, will capture only a fraction of the potential gains. If Federal energy efficiency is viewed as worth pursuing more vigorously, **dedicating resources** to it in the form of staffing and investment funding is essential. Dedicating resources naturally entails initial costs, although those should be rapidly paid back by reduced energy costs. Several other potentially useful options such as setting standards of performance, revising procurement policies, and creating incentives for agencies and personnel require modest or negligible initial costs and are grouped here as **encouraging agency efforts**. Finally, **promoting research, development, and demonstration** can be useful not only in developing new energy efficient technologies, but for ensuring that current experiences translate into improved policies for the future.

Maintaining the Status Quo

Current Federal efforts together with a general improvement in the efficiency of HVAC and lighting equipment on the market should help to gradually improve Federal energy efficiency. However, the improvements will be only a fraction of the available cost-effective energy- and cost-saving measures. At the current low level of energy efficiency funding and staffing for individual agencies, it would take decades to make all the economically attractive investments. During that time, tens of billions of dollars would be unnecessarily spent to buy inefficiently used energy.

Table 1-2—Policy Options for Federal Energy Efficiency

Maintaining the status quo

Dedicating resources
- Increasing funds for investment
- Supporting an adequate staff: using money wisely

Encouraging agency efforts
- Setting standards for performance
- Rewarding agencies and individuals for energy and and cost savings
- Revising procurement: information, life-cycle costing, and simplification
- Following through and enforcing

Promoting research, development, and demonstration

SOURCE: Office of Technology Assessment, 1991.

Dedicating Resources: Higher Priority for Energy Efficiency

There are several billion dollars' worth of highly cost-effective energy-efficiency investment opportunities in federally owned and assisted buildings. Many of these measures have very high returns on investment, several times higher than the Treasury's cost of funds. It appears that a gradual increase in Federal investment at least to the level of the early 1980s could produce high returns for the foreseeable future. One novel method of funding which could be considered is a revolving loan fund. Also, to help ensure that funding levels are appropriate, the Federal Energy Management Program could be required to provide estimates of the government-wide potential energy and cost savings and the capital investment required to attain those savings in its annual report to Congress.

Adequate funding alone is not enough to assure the greatest energy and cost savings for the Federal Government. **It is at least as important to have a trained, competent, and motivated staff at individual Federal facilities, in central and regional agency offices, and in offices such as FEMP dedicated to successful implementation of energy-saving measures.** As one step to ensuring appropriate staffing, Congress could require the agencies, the Office of Personnel Management, and FEMP to report on agency staffing (as well as investments) in FEMP's annual report to Congress. DOE's expertise in applying energy efficiency measures (e.g., the Institutional Conservation Program) could be a useful supplement to agency staff.

Encouraging Agency Efforts

Setting Standards—Some existing minimum standards or requirements for energy efficiency could be expanded. For example, Federal agencies are required by the Federal Energy Management Improvement Act of 1988 to reduce energy consumption in their existing buildings by 10 percent in 1995 relative to 1985. That requirement filled a void left when the energy-saving targets of Executive order 12003 lapsed in 1985. It is a modest goal, less by at least a factor of two than should be readily achievable using current commercial measures. Nevertheless, extending this requirement beyond 1995 together with a new minimum savings target based on life-cycle costs could help promote greater continuity in Federal energy efforts. Also, the standard could be expanded to include energy used in operations. The goals set by Executive Order 12759 provide agencies with valuable guidance. However, they are not based on an analysis of existing opportunities and could potentially be strengthened.

Creating Incentives—Creating more rewards for Federal agencies and for facility staff that successfully pursue energy-and cost-saving measures is one way to promote implementation of efficiency efforts. Although incentives for energy performance have been the exception rather than the rule in Federal facilities, the exceptions are useful models which could be more broadly applied. For example, the incentives for DOD facilities included in the National Defense Authorization Act for fiscal year 1991 could be expanded to other agencies. DOD's new incentives need to be monitored to ensure that they are being properly and fully implemented, and revised as necessary. Also, part or all of GSA's bonus program for facility personnel in its National Capitol Region may be worth replicating in other regions and other agencies. Key issues in establishing an incentive system include which facilities and personnel should be eligible for awards, the methods used to demonstrate that energy and cost savings actually occur, the amount of the awards, and in the case of agency incentives, possible restrictions on the use of incentive funds.

Revising Procurement—Some Federal procurement policies could be revised to encourage greater use of energy efficient products and services. There are several possible changes in the procurement system which may be worth considering. One possibility is to provide information on energy use characteristics of products provided to agencies by the Federal Supply Schedule Program, through the Federal Supply Catalog managed by GSA, and of the lighting products provided by the Defense Logistics Agency. A second possible procurement change is to increase the use of life-cycle costing when selecting goods and services ranging from light bulbs and ballasts to service contracts for HVAC equipment operation and maintenance. A third possibility is to simplify some procurement policies for new energy efficient products and services. This is particularly important since many energy efficiency measures are relatively new. For example, changing the regulations governing SES contracts to simplify them and increase agency flexibility may help promote that novel form of private financing of Federal efficiency measures.

Following Through and Enforcing—Finally, following through on Federal energy management programs is essential to achieving full energy- and cost-saving potential. Ongoing congressional attention helps raise the priority of energy efficiency efforts within Federal agencies. To further demonstrate ongoing interest, Congress could consider encouraging regular or occasional reports by inspector generals at the key agencies with most responsibility for Federal energy use and management.

Promoting Research Development

Continuing and possibly expanding research, development, and demonstration (RD&D) efforts is important to innovation and the practical application of new energy efficient measures. But even for economically attractive new commercial products, gaining consumer acceptance and widespread use both within the government and the private sector takes considerable time and could benefit from increased demonstration efforts and information sharing. Research into preferences and perspectives of facility managers can be useful in developing programs which best deliver energy- and cost-saving technologies. By demonstrating the cost and performance of efficient technologies and operating strategies to the maximum cost-effective potential in at least some of its own facilities, the Federal Government could help reduce the risk and uncertainty perceived by managers both in other Federal facilities and in the private sector.

Chapter 2

Policies and Programs for Federal Energy Efficiency

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Chapter 2

Policies and Programs for Federal Energy Efficiency

Since the 1970s, both the executive branch and Congress have worked to promote energy efficiency within Federal agencies, although policy emphasis has varied. This chapter first examines legislative and executive efforts to implement an energy conservation strategy for the Federal Government. Next it describes the major energy efficiency programs of Federal agencies intended to implement congressional and executive policy.[1]

SETTING GOALS: LEGISLATION AND EXECUTIVE ORDERS PROMOTING FEDERAL ENERGY EFFICIENCY

Legislation for Federal Facilities and Operations

Congress has visited the issue of improving energy efficiency in the facilities it owns and leases and in its operations several times since the mid-1970s. Each new piece of legislation has combined past experience with new approaches in an effort to promote further efficiency gains in Federal agencies. Table 2-1 summarizes the main acts of Congress regarding Federal energy management legislation, and the key provisions.

Energy Policy and Conservation Act (EPCA)—EPCA of 1975 was the first major piece of legislation to address Federal energy management, directing the President to develop a comprehensive energy management plan including procurement practices and a 10-year building plan. EPCA included few details, leaving those to the executive branch. EPCA also amended the Motor Vehicle Information and Cost Savings Act to require that the Federal automotive fleet meet or exceed the corporate average fuel economy mileage standards.

Department of Energy Organization Act (DOEOA)—Section 656 of the DOEOA of 1977 established the Federal Interagency Energy Policy Committee (often called the "656 Committee"). The 656 Committee is a senior agency management group comprised of an assistant secretary or assistant administrator from each of the Departments of Defense, Commerce, House and Urban Development, Transportation, Agriculture, and Interior; from the U.S. Postal Service and from the General Services Administration. The National Aeronautics and Space Administration and the Department of Veterans Affairs have also designated members for the committee. This committee meets periodically to discuss policy options and review agency progress toward Federal conservation goals. The committee is intended to strengthen energy conservation programs which emphasize productivity through the efficient use of energy and to concurrently encourage interagency cooperation in energy conservation. One of its purposes is to focus the attention of top Federal agency management on the tasks and missions related to national energy objectives rather than on the tasks of a particular agency.

National Energy Conservation Policy Act (NECPA)—In NECPA of 1978, Congress took a more active role in defining detailed steps to be followed by the executive agencies. Several of the steps included in this legislation had been set forth by the President in Executive Order 12003 in 1977 (see below). For example, where EPCA directed the President to develop an energy-related procurement policy, NECPA specified the use of a "life cycle costing methodology" as the basis of policy. Similarly, where EPCA directed the President to develop a 10-year building plan, NECPA included details such as which buildings were subject to energy audits (all those exceeding 1000 square feet). Both of these provisions in NECPA were part of Order 12003. Unlike Order 12003, NECPA set no goal for percentage reduction in energy use, but instead specified the minimum rate at which Federal buildings had to be retrofit with all cost effective measures. All buildings were to have been retrofit by

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[1] In addition to the efforts to improve Federal energy efficiency, Congress and the Department of Energy are working to promote energy efficiency throughout the economy at large. These efforts will produce increased efficiency for the Federal Government as well. For example, the National Appliance Energy Conservation Act, with energy efficiency standards for products ranging from refrigerators to fluorescent light ballasts, will result in energy savings over time as agencies replace existing equipment.

Table 2-1—Federal Energy Management Legislation

Law	Purpose	Provisions for Federal Energy Management
EPCA 1975	To increase domestic energy supplies and availability; to restrain energy demand; to prepare for energy emergencies.	Directs President to: —Develop mandatory standards for agency procurement policies with respect to energy efficiency; —Develop and implement 10-year plan for energy conservation in Federal buildings, including mandatory lighting, thermal, and insulation standards, and plans for retrofitting to meet standards. Requires that Federal vehicle fleet meet corporate average fleet efficiency standards.
DOEOA 1977	Establishes department of energy to secure effective energy management and a coordinated national energy strategy.	Establishes "656" Committee.
NECPA 1978	Promote the use of commonly accepted methods to establish and compare life-cycle costs of operating Federal buildings, and the use of solar heating and cooling and other renewable energy sources in Federal buildings	Defines Federal Energy Initiative (FEI). Establishes use of life-cycle cost (LCC) method. Establishes publication of Energy Performance Targets. Requires LCC audits and retrofits of Federal buildings by 1990. Establishes Federal Photovoltaic Program. Establishes Federal Solar Program.
COBRA 1985	Reconcile the budget.	Amends FEI authorizing agencies to use shared energy savings (SES).
FEMIA 1988	Promote efficient use of energy by the Federal Government.	Amends Federal Energy Initiative. Allows Secretary of Energy to set discount rate used in LCC analysis. Removes requirement that agencies perform LCC retrofits by 1990. Establishes energy performance goals for Federal buildings, including a 10% reduction in building energy use by 1995. Directs agencies to establish incentives for energy conservation. Creates Interagency Energy Management Task Force on Federal energy management.
NDAA for FY89, Sec. 736 1988	Authorizes defense spending.	Establishes incentive for SES contracts in DOD, allowing half of first year savings to be used for welfare, morale, and recreation activities at facility. Other half to be used for additional conservation measures.
NDAA for FY90 Sec. 331 1989	Same as above.	Expands DOD's SES incentive to include half of first 5 years' savings.
NDAA for FY91 Sec. 2851 1990	Same as above.	Requires Secretary of Defense to: —Develop plan "to achieve maximum cost-effective energy savings;" —Develop simplifed contracting method for SES; —Report annually to Congress on progress made. Expands DOD incentives to include utility rebate programs and include two-thirds of savings.

KEY: EPCA—Energy Policy and Conservation Act, 1975, Public Law 94-163.
DOEOA—Department of Energy Organization Act, 1977, Public Law 95-91.
NECPA—National Energy Conservation Policy Act, 1978, Public Law 95-619.
COBRA—Comprehensive Omnibus Budget Reconciliation Act. 1985, Public Law 99-272.
FEMIA—Federal Energy Management Improvement Act, 1988, Public Law 100-615.
NDAA—National Defense Authorization Acts: for FY 1989, Public Law 100-456; for FY90, Public Law 101-189; for FY91, Public Law 101-510.

SOURCE: Office of Technology Assessment, 1991.

1990. The main provisions of NECPA were codified as the Federal Energy Initiative.[2]

Comprehensive Omnibus Budget Reconciliation Act (COBRA)—COBRA of 1985 amended NECPA to provide Federal agencies an alternative source of funding for energy efficiency investments during a time of great fiscal constraints. Under COBRA, agencies were encouraged to seek private financing and implementation of energy efficiency projects through "shared energy savings" (SES) contracts (described below).

Federal Energy Management Improvement Act (FEMIA)—FEMIA of 1988 amended NECPA and modified and added several provisions to the

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[2] 42 U.S. Code 8243-8287 (1983).

Federal Energy Initiative. A central provision was the establishment of a goal to reduce energy consumption per square foot in Federal buildings by 10 percent between 1985 and 1995. Operations energy (i.e., energy used for transport, or in energy-intensive activities such as nuclear reactors) was not included. FEMIA marked the first time that Congress specified the level of savings which should be achieved. Also, as an incentive to encourage use of SES contracts, Congress allowed agencies to retain a portion of cost savings for future energy conservation measures. Furthermore, FEMIA created an Interagency Energy Management Task Force, and directed the Department of Energy (DOE) to carry out an energy survey in a representative sample of Federal buildings to: 1) determine the maximum potential cost-effective energy savings that may be achieved, and 2) make recommendations for cost-effective energy efficiency and renewable energy improvements.

National Defense Authorization Acts for Fiscal Years 1989-91 (NDAA)—NDAA for 1989 provided incentives for shared savings in military facilities by allowing a base commander to use half the first-year savings for welfare, morale and recreation activities of the base. NDAA for 1990 expanded that incentive to cover the savings in the first 5 years. NDAA for 1991 revised the incentive such that one-third of the savings from SES contracts could be used for additional energy conservation measures, with one-third left for improving family housing at the base or for welfare and recreation activities. Further, these incentives apply not only to SES contracts, but also to other energy cost savings (e.g., from participation in utility rebate programs). NDAA for fiscal year 1991 also calls for simplified SES contracting methods, explicitly allows military facilities to participate in utility rebate programs, and directs the Secretary of Defense to develop and report annually on a plan to achieve maximum cost-effective energy savings through the year 2000.

Proposed Legislation—Congress has continued to work for increased energy savings in Federal facilities with ongoing hearings and proposed legislation. For example, the House Energy and Commerce Committee's Subcommittee on Energy and Power and the House Government Operations Committee's Subcommittee on Energy, Environment and Natural Resources held a joint hearing in July 1990 on energy conservation and efficiency efforts at Federal facilities.[3] In addition to hearings on the issue, new legislation has been proposed. For example, the proposed National Energy Policy Act of 1990, which passed the Senate in August 1990, included a goal of installing all conservation measures with less than a 10-year payback period in Federal buildings.[4] Currently, there is proposed legislation in both Houses which includes a variety of provisions for improving Federal energy efficiency.[5] For example, several of these acts, if enacted, would establish a fund to support energy efficiency investments and direct agencies to perform energy- and cost-saving retrofits and create new incentives.

Legislation for Households Receiving Federal Energy Subsidies

Around two-thirds of the Federal Government's spending on energy is for Federal facilities and operations. The other third is spent indirectly on the utility bills of low-income households through programs of the Departments of Housing and Urban Development (HUD) and Health and Human Services (HHS).[6] As with the Federal Energy Initiative, legislative efforts to encourage increased energy efficiency in HHS- and HUD-assisted households have been ongoing and have evolved over time.

Energy Efficiency in HUD-Assisted Housing—The Housing and Community Development Act (HCDA) of 1974 placed an emphasis on energy conservation and renewable energy. HUD was directed to support activities related to energy, including retrofits and installation of solar equipment in buildings, and to provide aid for the assessment and design of district heating and cooling systems and resource recovery projects.

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[3] U.S. Congress, House Committee on Energy and Commerce, Subcommittee on Energy and Power, and House Committee on Government Operations, Subcommittee on Environment, Energy, and Natural Resources, *Hearings on Federal Facilities Energy Conservation Programs*, Serial No. 101-175, July 1990.

[4] S. 324 passed the Senate with an amendment by voice vote on Aug. 4, 1990 (Congressional Record, Aug. 4, 1990, pp. 12558-12596).

[5] See S. 163, introduced Jan. 14, 1991; S. 326, introduced Jan. 31, 1991; S. 341, introduced Feb. 5, 1991; S. 417, introduced Feb. 7, 1991; S. 570, introduced Mar. 6, 1991; S. 741, introduced Mar. 21, 1991; H.R. 776, introduced Feb. 4, 1991; H.R. 1196, introduced Feb. 28, 1991; H.R. 1301, introduced Mar. 6, 1991; and H.R. 1543, introduced Mar. 21, 1991.

[6] These programs are described in ch. 3.

The HCDA of 1979 directed that HUD consider life-cycle cost when selecting heating and cooling systems in newly constructed and substantially rehabilitated projects.[7] The HCDA of 1980 required the preparation of comprehensive, communitywide energy use strategies. The HCDA of 1987 established an energy-efficient public housing demonstration project, allowed housing authorities to retain part of the energy cost savings resulting from shared energy savings projects, and required that life-cycle cost be considered in HUD's comprehensive improvement assistance program for housing authorities.

The Cranston-Gonzalez National Affordable Housing Act of 1990 required that newly constructed HUD-assisted housing meet energy efficiency standards. It also included a low-income housing conservation and efficiency grant, and required that HUD submit an energy assessment report and a 5-year energy efficiency plan.

Energy Efficiency in DOE and HHS-Assisted Households—In 1989 HHS spent $1.4 billion on residential heating and cooling assistance payments through the Low Income Home Energy Assistance Program (LIHEAP). Congress has established two programs to improve energy efficiency in low-income households. One is a weatherization component of LIHEAP. The other is DOE's Weatherization Assistance Program (WAP), which is not limited to LIHEAP-eligible households, but targets generally the same population. Under LIHEAP, the States are allowed to use up to 15 percent of LIHEAP funding for weatherization programs. In 1990, Congress amended LIHEAP to allow States to request a waiver to spend up to 25 percent of their LIHEAP funds on weatherization under certain conditions.[8] The maximum weatherization benefit ranged from $160 to $5,000 in fiscal year 1990, which aided about 160,000 households in weatherizing their homes. In recent years, 8 to 10 percent of LIHEAP funds have been used for weatherization. A relatively small number of LIHEAP-eligible households receive weatherization. For example, in fiscal year 1989, less than six-tenths of 1 percent (or 142,584 households) received weatherization assistance.[9] Since 1985 there have been substantial cuts in LIHEAP funding, and use of LIHEAP for weatherization has decreased significantly. For example, in the fiscal year 1992 budget request, HHS suggested reducing the LIHEAP appropriation by one-third to around $1 billion.[10] Between fiscal year 1988 and 1990 the weatherization assistance component has dropped by 22 percent, from $170 million to $133 million.

DOE's WAP was established in 1977 by Title IV of the Energy Conservation and Production Act.[11] Through WAP, Congress directed the Secretary of Energy to develop and conduct a weatherization program that provides grants to States and Indian tribes. Households with incomes below 125 percent of the Federal poverty line (around $6,000 in 1988) are eligible to have additional home insulation installed. States often use LIHEAP weatherization funds to supplement WAP. In 1988, 107,000 homes were weatherized with a maximum average expenditure of $1,600 per housing unit. The appropriations levels have remained relatively constant in recent years, hovering around $160 million, although when inflation is taken into account funding has fallen.[12]

Executive Orders for Federal Energy Efficiency

Executive Order 11912—There have been five Executive orders related to Federal energy efficiency. The earliest was Order 11912 of 1976, Delegation of Authorities Relating to Energy Policy and Conservation. Among other things, this order defined the roles of various Cabinet Departments with responsibility for Federal energy use:

- the Administrator of the General Services Administration (GSA) was designated to take on the functions assigned to the President by the Motor Vehicle Information and Cost Savings Act, as amended, directing that rules be established to require the Federal fleet to achieve an average fuel economy of at least that applicable to vehicle manufacturers;

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[7] 42 U.S.C. 1437k (1990, Cumulative Annual Pocket Part).

[8] Public Law 101-501, Nov. 3, 1990.

[9] U.S. Department of Health and Human Services, Family Support Administration, *Low Income Home Energy Assistance Program Report to Congress for Fiscal Year 1989*, Oct. 29, 1990, p. ix.

[10] U.S. Office of Management and Budget, *Budget of the United States Government Fiscal Year 1992* (Washington, DC: U.S. Government Printing Office, 1991), Part 4-667.

[11] 42 U.S.C. 6851 (1983).

[12] Mary F. Smith and Joe Richardson, Library of Congress, Congressional Research Service, "CRS Report to Congress: Weatherization Assistance Programs of the Departments of Energy and Health and Human Services," June 6, 1990, p. 4.

- the Administrator of the Federal Energy Administration (now the Secretary of Energy) was made responsible for coordination of a 10-year energy conservation plan for Federal buildings, energy conservation and rationing contingency plans, and preparation of annual reports to be submitted to Congress as required by EPCA; and
- the Administrator of the Office of Federal Procurement Policy was required to provide policy guidance for application of energy conservation and efficiency standards in the Federal procurement process as mandated by EPCA.

Executive Order 12003—Order 12003, issued in 1977, amended Order 11912 and aggressively expanded the requirements of the Energy Policy and Conservation Act of 1975. For example, it specified a goal of a 20-percent reduction in energy use per square foot in existing Federal buildings, and required the Federal automobile fleet to exceed the minimum statutory requirement by 4 miles per gallon beginning in fiscal year 1980. As noted above, some of its provisions are also found in NECPA. Key provisions of Order 12003 include the following:

- The Administrator of the Federal Energy Administration (now the Secretary of Energy) was directed to:
  1. develop, implement and oversee a 10-year energy conservation plan for Federal buildings over 5,000 square feet for the 1975-85 period which would achieve a 20 percent reduction in energy use in existing buildings and a 45 percent reduction in all new buildings;[13]
  2. establish a life-cycle-cost methodology; and
  3. report to Congress annually on the progress of the plan.[14]
- The Administrator of GSA was directed to ensure that:
  1. all passenger automobiles purchased by executive agencies exceed the manufacturers' corporate average fuel economy standard under the Motor Vehicle Cost and Information Act;
  2. the Federal passenger automobile fleet exceed minimum statutory requirements by 2 miles per gallon in fiscal year 1978, and by 4 miles per gallon beginning in 1980; and
  3. the Federal light truck fleet also meet minimum standards, although not required under the Motor Vehicle Cost and Information Act.

Executive Order 12083—In 1978, Order 12083 created an Energy Coordinating Committee, composed of the Secretaries of the major Federal agencies. Its mission is to assure Federal coordination on energy-related matters, including both policy initiatives and resource allocation. In addition to the committee, an Executive Council was formed—consisting of the Secretary of Energy, Chairman of the Council of Economic Advisers, Assistant to the President for National Security Affairs, and the Assistant to the President for Domestic Affairs and Policy—to fulfill the functions of the committee during periods when the committee is not meeting.

Executive Order 12375—Order 12375 of 1982 further amended Order 11912 to reduce the required Federal passenger automobile fleet efficiency established in Order 12003. Whereas Order 12003 required the Federal passenger fleet to exceed manufacturers' average fleet efficiency by 4 miles per gallon, Order 12375 required only that the Federal fleet meet the manufacturers' average efficiency and that light trucks meet standards set by the Secretary of Transportation.[15] This Executive order contrasted sharply with Order 12003, which was far more ambitious and went beyond some minimum requirements set by Congress.

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[13] Note, as specified in 10 CFR 436 which interprets the Executive order, agency goals and reports are based on both energy used at the source and energy used at the site. The distinction applies to electric energy use to account for efficiency losses in generation, transmission, and distribution. While each kilowatt-hour of electricity is equal to 3,412 Btus at the site, on average 11,600 Btus of fossil fuels are required to generate and deliver it. The source accounting system makes each unit of electric energy 3.4 times as important as each unit of fossil energy. Because source accounting reflects generation and distribution losses, DOE's reports have historically emphasized it. Beginning in 1990, agencies decided to emphasize energy use based on site rather than source accounting in future reporting. Tina Van Sickle, Federal Energy Management Program, U.S. Department of Energy, personal communication, March 1991.

[14] 42 *Federal Register* 37523 (July 20, 1977).

[15] 47 *Federal Register* 34105 (Aug. 4, 1982).

Executive Order 12759—On April 17, 1991, Order 12759 was issued with provisions to:

- extend the FEMIA Federal building reduction goal to 2000, requiring Btu per gross square foot to be reduced 20 percent from 1985 levels;
- require agencies to prescribe policies for improving energy efficiency of industrial facilities by at least 20 percent in 2000 compared to 1985;
- minimize petroleum use;
- procure energy-efficient goods and products by Federal agencies based on life-cycle cost;
- provide for Federal agency participation in demand-side management services offered by utilities;
- provide new Federal vehicle fuel efficiency requirements, and outreach programs; and
- promote procurement of alternative fuel vehicles for Federal fleet.

Development of the order, underway since 1989, received considerable support from members of Congress. For example, in April 1990, 19 Senators sent a letter to President Bush urging the issuance of a new Executive order, asking that the order direct the Office of Management and Budget (OMB) and Federal agencies to "implement cost-effective energy efficiency projects, including the steps necessary to encourage private sector and utility assistance in financing such projects."[16] In September 1990, 66 members of Congress sent a letter to the Secretary of Energy again supporting an Executive order.[17]

PROGRAMS FOR IMPLEMENTING CONGRESSIONAL AND EXECUTIVE POLICY

Each Federal agency is responsible for implementing energy management plans for its facilities and operations as part of the Federal Energy Initiative (see above). The approaches taken by the individual agencies are diverse, reflecting the wide range of their missions and perceived opportunities. However, several programs, such as life-cycle cost in procurement and SES, have broad relevance across all Federal agencies. The main ones are listed in table 2-2 and described in the following sections.

Table 2-2—Governmentwide Approaches to Energy Efficiency

- Coordination of Federal efforts by DOE's Federal Energy Management Program
  - Reporting on Federal energy management efforts
  - Providing information, training, and technical support
  - Hosting interagency committee meetings
  - Awarding certificates of achievement
- Life-cycle costing for procurement
  - GSA's Federal supply service
  - Defense Logistics Agency
- Shared energy savings contracts
- Utility rebate programs
- Energy performance standards for new Federal buildings
- Surveys of efficiency opportunities based on life-cycle costs

SOURCE: Office of Technology Assessment, 1991.

DOE's Federal Energy Management Program

The Federal Energy Management Program (FEMP) within the Department of Energy is the central mechanism that coordinates Federal energy-efficiency efforts. It has several objectives, including:

- encouraging better understanding of how energy is used in the Federal sector;
- generating energy efficiency expertise, techniques, and practices and sharing them with other agencies;
- identifying key energy managers and Federal decisionmakers; and
- promoting effective energy management practices through training and awareness of these managers.[18]

FEMP has a leadership role in guiding other Federal agencies to develop sound energy management practices, but has no responsibility for other agencies' programs. It is a small office, with a staff of six and annual funding averaging $1.5 million between 1985 and 1990. FEMP's 1991 appropriations have been increased to $3 million.

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[16] U.S. Department of Energy, "Federal Interagency Energy Management Task Force Holds First Meeting," *Federal Energy Management Activities*, DOE/CE-0281P, Spring 1990, p. 7.

[17] The Honorable Philip R. Sharp et al., U.S. Congress, letter to the Honorable James D. Watkins, Secretary, U.S. Department of Energy, Sept. 11, 1990.

[18] U.S. Department of Energy, Office of Conservation and Renewable Energy, "Annual Operating Plan of Federal Energy Management Program," December 1989, p. 3.

FEMP pursues a strategy "to seek those activities that produce the maximum energy efficiency payoff with minimum expenditures."[19] Currently, FEMP has four areas of operations: 1) reporting on Federal energy management efforts; 2) providing information, training, and technical support to Federal agency personnel; 3) hosting interagency meetings to develop new Federal initiatives (e.g., a new Executive order); and 4) annually awarding certificates of achievement to Federal facilities and personnel that have demonstrated exemplary performance.

Annual Report—Each year, FEMP produces a report to Congress describing the Federal energy management activities. Each executive agency reports quarterly and annually to FEMP on energy use in its facilities and operations. FEMP compiles these reports and publishes them in an annual report, *Federal Government Energy Management and Conservation Programs*. The report is descriptive, presenting statistics on energy use and spending by agency, and summary information on Federal investments in energy efficient equipment and the number of shared savings contracts entered into and completed. The report contains no independent analysis by FEMP staff and no discussion of the existing opportunities for improving energy efficiency.

Information, Training, and Technical Support—The bulk of FEMP's efforts are in providing training and technical support to other agencies. These activities include publishing a quarterly newsletter, publishing occasional guidebooks (e.g., *Architect's and Engineer's Guide to Energy Conservation in Existing Buildings*[20]), conducting training classes on topics such as life-cycle cost and SES contracts, and sponsoring four mobile energy labs for use by Federal facilities.

The *FEMP Update* is a quarterly newsletter distributed to over 5000 facility and management personnel whose jobs are directly related to energy use. Most of the articles in *Update* are submitted by its readers, providing a forum for Federal personnel to share their experiences with new energy efficient technologies and programs. The dozen or so articles in each issue describe a small but diverse sample of the efforts pursued by different agencies.

To familiarize Federal facility engineers, managers, and planners with Federal requirements instituted by FEMIA, FEMP together with GSA have developed training courses on SES contracts and life-cycle cost methods. In addition to FEMP courses, there are several private-sector and individual agency training courses on a wide range of energy management topics, as discussed in box 2-A.

Only a small fraction of the 5000 major Federal facilities have sent personnel to FEMP's training courses. For example, through June 1990, 169 Federal employees attended one of the eight SES training courses offered.[21] In 1990, between 25 and 50 Federal employees, down from previous years,[22] took FEMP's combined life-cycle cost/a simplified energy analysis method (ASEAM) course. These courses could have an impact nonetheless. For example, if even 3 percent of the 169 Federal employees trained in SES in 1989 successfully implemented a SES, the number of SES contracts completed through 1990 would more than double.

DOE's life-cycle cost training course is intended to ease the transition from making decisions based on traditional least first cost to least life-cycle cost. It describes techniques for selecting the most cost-effective building energy projects. The course includes instruction on a computer simulation program which helps managers estimate energy savings and perform life-cycle cost analyses. The computer program, called ASEAM-2, is available to all Federal facility engineers and associated facility managers to analyze building energy requirements. Energy analysis and life-cycle cost analysis is naturally complex, and some agencies still report that it remains too complex for use. For example,

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[19] U.S. Department of Energy, Office of Conservation and Renewable Energy, "Annual Operating Plan of Federal Energy Management Program," December 1989, p. 4.

[20] Pacific Northwest Laboratory, *Architect's and Engineer's Guide to Energy Conservation in Existing Buildings*, DOE/RL/0183P-H4, vol. 1 and 2, April 1990.

[21] Ted Collins, Federal Energy Management Program, U.S. Department of Energy, personal communication, November 1990.

[22] Dean Devine, Federal Energy Management Program, U.S. Department of Energy, personal communication, Jan. 17, 1990.

Box 2-A—Energy Training Courses

Training is a necessary ingredient in a successful energy management program in the government. Energy managers must make decisions that involve rapidly changing technology, limited budgets, vacillating energy costs, and the occupant in the facility. To aid Federal energy managers, many training courses are available, both private and government-offered.

The courses address a broad scope, ranging from the particulars of boilers to lighting retrofit options to the applicability of economic analyses. Since 1989 the Federal Energy Management Program and the General Services Administration have offered two courses, Shared Energy Savings Contracts and Life-Cycle Cost Methods/A Simplified Energy Analysis Method, to facility engineers, managers, and planners. Courses are also offered by professional societies, like the American Society of Heating, Refrigeration, and Air Conditioning Engineers and the Association of Energy Engineers, by universities such as the University of Wisconsin at Madison and Virginia Polytechnic Institute, and by manufacturers (e.g., General Electric's Lighting Institute).

The private sector courses define a number of objectives: cutting costs, improving efficiency, and dispersing knowledge concerning relevant technology. Most are seminars in which a variety of applications are discussed. Many provide hands-on training and identify solutions to foreseeable obstacles. For example, Virginia Polytechnic Institute offers an Energy Management Diploma Program that is completed in four courses. The institute states that their objective in offering the program, now in its 11th year, is to "get the participants into the energy management mainstream so that they know where the resources are that can help them."[1]

In 1989, 169 Federal employees, including 60 military personnel, attended one of the eight offered SES training courses. ASHRAE reported that 15 of the 339 applicants for its fall 1990 courses were Federal employees.[2] GSA/FEMP courses cost about $200, while private sector courses are $435 to $850 at the government rate. The benefits of well selected training should produce greater savings than the cost of sending the employee.

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[1] Letter and enclosures from William A. Mashburn, Associate Professor, Virginia Polytechnic Institute, Nov. 27, 1990.

[2] Marietta Henry, American Society of Heating, Refrigerating, and Air Conditioning Engineers, Fax on Federal employee participation in fall 1990 ASHRAE Professional Development Seminars, Nov. 6, 1990.

when ASEAM was first introduced in FEMP courses in 1988, many found the computer program (which required 16 floppy disks) daunting.[23] The FEMP life-cycle cost course including ASEAM is completing its second year, and feedback from the first students should aid future participants.

FEMP sponsors four mobile energy laboratories (MELs) which can perform detailed measurement and analysis of facility energy use. The MELs are converted passenger buses containing sophisticated energy monitoring, auditing, and analysis equipment, as well as a mobile work space for engineers and technicians. Currently, the Army, Air Force, Navy, and DOE each are assigned one of the MELs.[24]

Finally, FEMP provides individual assistance to agencies and facilities when requested in developing and implementing new programs. For example, FEMP is currently working with GSA and Potomac Electric Power Co. (PEPCO) to promote a relighting initiative. This initiative has three main benefits: 1) providing a clear demonstration of new, energy-efficient but commercially available lighting technologies as an example for other facilities; 2) demonstrating use of a utility rebate program (PEPCO is adding $10 million to GSA's $10-million effort; and 3) implementing a highly cost-effective, energy-saving measure.

Hosting Interagency Policy Meetings—FEMP regularly hosts the meetings of two interagency committees, one oriented to policy development and the other oriented to policy implementation. The focus of the recent meetings of these two committees has been development of a new Executive Order on Federal energy management (see above).

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[23] Trevor L. Neve and Robert W. Salthouse, Logistics Management Institute, "Making Shared Energy Savings Work," Report AL703R1, July 1988, p. 3-7.

[24] Pacific Northwest Laboratory, *Mobile Energy Laboratory Use Plan* (Washington, DC: U.S. Department of Energy, April 1989).

As required by law, the 656 Committee has convened annually the past 3 years. However according to the minutes of the committee meetings, no senior agency personnel have attended, with the exception of DOE's Assistant Secretary of Conservation and Renewable Energy.[25] Instead, the designated members have sent representatives.

The second committee hosted by FEMP is the Interagency Management Task Force, created by FEMIA in 1988. This committee is composed of the energy chiefs of all Federal agencies. It meets periodically to assist the 656 Committee in coordinating promotion of energy conservation activities within the Federal Government. This committee is responsible for assessment of agency progress in achieving energy savings, collection and dissemination of information relevant to energy savings, coordination of energy surveys conducted by the agencies, development of options for use in conserving energy, and reporting to the 656 Committee on its findings.[26] Since its inception the task force has met three times beginning in June 1990. Generally, the members of the task force are the same personnel who have substituted at the 656 meetings in the past 2 years.

Federal Energy Efficiency Awards—Each year, FEMP awards certificates of achievement to about 15 individuals and 15 facilities who have demonstrated exemplary performance in promoting conservation in Federal facilities. These awards include no financial reward, but rather provide recognition and favorable publicity for exemplary performance.

Life-Cycle Costing for Procurement

The Federal Government procures a great variety of energy-related goods and services, and procurement policies are correspondingly diverse. For example, procurement policy determines how gas and electric utility service is obtained; whether and how facilities use private contractors to perform heating, ventilation, and air conditioning system operation and maintenance; and which commonly used items (such as lamps and refrigerators) are available through the Federal Supply System.

Consideration of life-cycle cost is often required for Federal procurement (see box 2-B). Implementation of that requirement varies depending on the good or service being procured. Life-cycle cost analyses are generally left to individual agencies or facility managers to perform, but in some cases they are given explicit guidance.

Two Federal agencies take the lead in procuring the most commonly required products for the entire Federal Government, including energy-consuming or energy-conserving items such as lamps, household appliances, and office equipment. The Department of Defense's (DOD) Defense Logistics Agency is responsible for supplying lamps and associated equipment to all Federal agencies. GSA's Federal Supply Service is responsible for other common products and services. Of the thousands of products available from these two agencies, a few have been chosen based on their life-cycle cost, including household products such as refrigerators, water heaters, and room air conditioners listed on GSA's Household Appliances Schedule. For most other energy-using products such as lamps, agencies purchasing from the Defense Logistics Agency and the Federal Supply Service are given little or no guidance as to life-cycle cost.[27] GSA selects office products such as copiers and typewriters based on life-cycle cost, too, but energy costs are not considered since they are small compared to factors such as equipment durability and other operating costs (e.g., toner for copiers and ribbons for typewriters).[28]

Shared Energy Savings

Under COBRA, all Federal agencies are allowed to seek private sector financing and implementation of energy efficiency projects. The SES program permits Federal facilities to enter into contracts of up to 25 years with private energy service companies. Under SES contracts, private companies may perform energy services using their own capital and personnel for energy efficiency improvements including energy audits, purchase and installation of new equipment, operation and maintenance of equipment, and personnel training. In exchange, the contractors receive a specified portion of the cost

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[25] U.S. Department of Energy, 656 Committee Meeting Minutes, Feb. 29, 1988, Dec. 22, 1989, Oct. 10, 1990.

[26] 42 U.S.C. 8257 (1990, Cumulative Annual Pocket Part).

[27] U.S. Department of Energy, Federal Energy Management Program, "Annual Report to Congress on Federal Energy Conservation Programs, 1987," September 1988, p. 2.

[28] Mike Smith, Federal Supply System, General Services Administration, personal communication, Jan. 29, 1991.

Box 2-B—Life-Cycle Cost Analysis

The Energy Policy and Conservation Act (EPCA), passed in 1975, directed the President to develop procurement policies with respect to energy conservation opportunities.[1] NECPA of 1978 went further, specifying that agencies must consider life-cycle costing in procurement decisions. This requirement has been incorporated in Office of Management and Budget guidelines for general procurement including the full range of goods and services.[2] In addition, the Office of Federal Procurement Policy has developed standards for energy conservation which have been incorporated into the Federal Acquisition Regulations.

Use of life-cycle cost methodology by Federal agencies was introduced by Executive Order 12003 in 1977, codified by NECPA in 1978 and amended by FEMIA 10 years later. The life-cycle cost method assesses energy costs and savings potential over the total lifetime of a building or project to allow agencies to prioritize conservation projects and provide funding to those with the highest life-cycle cost savings: investment ratio (SIR). The method was designed by the Department of Energy as a way to estimate and compare different energy-use systems and evaluate new building designs and retrofit actions, not just for initial costs, but for total costs over the estimated lifetime of the project, system, or building. The National Bureau of Standards defines the method as follows:

> A method of economic evaluation that sums discounted dollar costs of initial investment (less salvage value), replacements, operations (including energy usage), and maintenance and repair of a building or building system over the study period.[3]

Under the Federal Energy Initiative (FEI) as established by NECPA, Federal agencies were required to retrofit all buildings larger than 1,000 square feet with cost-effective measures by 1990. That requirement was dropped from the FEI by the Federal Energy Management Improvement Act of 1988. Currently, the life-cycle cost rule principally applies to alternative building systems and designs for either existing or new federally owned and leased facilities, solar energy projects, Federal photovoltaic projects and purchase of household appliances. Life-cycle cost must be considered when choosing between alternate retrofit options, new building design, new building systems, and in the selection of leased buildings.

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[1] 42 U.S. Code 6361 (1990, Cummulative Annual Pocket Part).

[2] Office of Management and Budget, Office of Federal Procurement Policy, "Federal Procurement Policy Concerning Energy Conservation," Policy Letter 76-1, August 1976; and "Performance of Commercial Activities," Circular A-76, August 1983.

[3] Rosalie T. Ruegg, U.S. Department of Commerce, National Bureau of Standards, "Life Cycle Costing Manual for the Federal Energy Management Program," NBS Handbook 135, 1987, p. xx.

savings. This system provides Federal agencies an alternative source of funding for energy efficiency investments during a time of great fiscal constraints. See box 2-C for examples of Federal SES contracts.

SES contracts are not without shortcomings. According to one DOE contractor report, direct Federal Government financing of a project results in savings 30 to 70 percent higher than the savings from a SES contract.[29] This is a natural outcome of sharing the savings with the contractor. In addition, SES requires considerable effort from contract specialists. Still, SES does allow energy efficiency investment when direct Federal financing is unavailable.

There have been far fewer SES contracts than originally expected. For example, the Congressional Budget Office projected that 30 SES contracts would be in effect in fiscal year 1988, saving the Federal Government $250 million over a 5-year period, fiscal years 1989-93.[30] The conference report on the legislation enabling SES contracts estimated 30 contracts averaging a savings of $0.5 million each. However, as of 1990 only four energy savings contracts have been awarded. Some SES requests for proposals (RFPs) issued by Federal agencies have been entirely unsuccessful, receiving no responses. For example, the Department of Veteran's Affairs received no responses to its 1986 RFP concerning the Medical Center at Perry Point, Maryland.

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[29] DHR Inc., "Analysis of Shared Savings vs. Direct Financing of Energy Retrofits in Federal Buildings," DOE/CS/10097-1, May 1984.

[30] U.S. Congress, Congressional Budget Office, "Cost Estimate for H.R 4065, the Federal Energy Management Improvement Act," May 26, 1988, p. 4.

Box 2-C—Examples of Efforts To Implement Federal Shared Energy Savings Contracts

Federal agencies have been authorized by Congress to use shared energy saving (SES) contracts since 1986.[1] By December 1990, five contracts had been signed, but one was terminated shortly thereafter. A larger number of SES contracts have been considered, but not brought to fruition. At the end of 1990, there were 16 proposals under development and 4 contracts under negotiation.

Because every Federal facility has a unique location, use, building style, and equipment, every SES contract is unique. The two successful examples (only one of which resulted in an SES contract) here illustrate some of the many issues which determine the success or failure of any SES project.[2]

Corpus Christi Army Depot: On September 7, 1988, the Army signed an SES contract for the Corpus Christi Army Depot. This project, which took over one and a half years to sign, illustrates the benefits of patience and flexibility.

The Army wanted to retrofit a chiller and upgrade electrical service in an aircraft hanger. The Request for Proposal (RFP) for the project was issued in early 1987, and a preproposal conference was held with potential contractors. The winning contractor was to provide all the materials, equipment, and labor to remove the outdated chiller and replace it with a modified system, bearing all costs of the operation for the 25-year period specified in the contract. For the first 6 months after the RFP was issued, the Army could find no interested prospective contractors.

Based on comments from a potential contractor, the Army altered the contract to include additional conservation measures to the chilled water system which would generate further savings and revised the shared savings formula. These changes were crucial to making the project worthwhile for the contractor, as well as increasing total savings. After over a year of negotiations, the contract was signed with Way Engineering Co., Inc. Under the contract, Way Engineering Co., Inc. will receive 68.6 percent of the energy cost savings. The chiller is now in operation and based on current usage rates, the contractor will receive $7.6 million and the government will save $3.5 million over the next 25 years.

Housing and Urban Development Headquarters: In 1987, the Department of Housing and Urban Development (HUD) proposed using an SES contract in HUD's Washington, DC headquarters building to install energy efficient lighting and heating, ventilation, and air conditioning equipment. The RFP required that all installation work on the project be done after normal office hours, which some potential bidders considered restrictive. The contractor was to provide 7-year maintenance service.

After HUD secured a bidder and started negotiations, GSA announced that it planned to install an automatic sprinkler system for fire safety. The sprinklers altered the economics of the SES project to such an extent that the project was terminated. The relighting is now being performed by GSA directly concurrent with the sprinkler installation.[3] Although the SES contract was terminated, the project's objective of improving energy efficiency will be met, with all the savings accruing to the Federal Government.

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[1] Comprehensive Omnibus Budget Reconciliation Act of 1985 (COBRA), Public Law 99-272, Title VII, 7201(a).

[2] Unless otherwise noted, these descriptions are derived from: U.S. Department of Energy, "Shared Energy Savings Contracting for Federal Agencies, Topic D Exhibits," DOE/CE-237, May 1990, pp. 4-6. For a description of the successful SES contract at the San Diego Division of USPS, see ch. 5.

[3] Department of Housing and Urban Development, "Energy Conservation Plan for Department of Housing and Urban Development Headquarters," Oct. 1, 1990, p. 7.

Three factors help explain the lack of SES contracts through 1989, as noted by the General Accounting Office.[31] First, until 1989, Federal facilities were not allowed to retain any of the savings, and agency officials lacked incentives for pursuing SES contracts. A second impediment was the complicated structure of SES contracts, which differ from conventional contracts. Provisions for estimating energy savings, design of payment provisions tied to energy savings and future energy prices, and the slower payback for contractors are examples of how SES contracts differ from conventional contracts. Coupled with a lack of detailed baseline energy-use data, developing energy and cost-saving estimates present an obstacle. Finally, uncertainty about procurement policy hampered SES efforts. For example, OMB Circular A-76 requires that agencies compare contractor cost to in-house cost for the particular service, but such comparisons are difficult to produce. Some agencies prepared voluminous and detailed RFPs to ensure compliance with procurement policies. However, contractors prefer flexible and limited RFPs because they cost less to respond to and afford opportunities to explore a wider range of energy-savings options in the facility.

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[31] For a detailed discussion of three of these reasons, see U.S. Congress, General Accounting Office, "Report to the Congressional Requesters on Federal Shared Energy Savings Contracting," GAO/RCED-89-99, April 1989, p. 1.

GAO's report noted that the impediments it identified in 1989 were being addressed. For example, Congress added some incentives in the Federal Energy Management Improvement Act of 1988 and the National Defense Authorization Acts for fiscal years 1989-91, as described above. Lack of baseline energy-use data was partially addressed through development of ASEAM, although calibrating the model remains difficult. Increased familiarity with SES contracts should result in a more flexible interpretation of procurement policy. However, other impediments remain, such as a reluctance of agency officials to relinquish potential savings to a private firm and a shortage of staff to identify and implement projects. Whether the new incentives and other changes are sufficient to promote more SES activity in the future remains an open question.

Utility Rebate Programs

In the past year, FEMP has encouraged all Federal agencies to make use of utility rebate programs for energy efficient equipment.[32] A large and growing number of the Nation's electric utilities and a few gas utilities offer such programs as part of their efforts to manage future demand. Many utility programs are well-funded and comprehensive.[33] Utility programs may also supplement facility staffs by providing engineering and other expertise. For example, Pacific Northwest Laboratory is working for FEMP with Niagara-Mohawk Power Corp., a New York utility, to develop a model program for Federal facilities. Program goals include having the utility provide 100 percent of the financing and also provide contractors to perform audits and implementation.[34] Also, as noted above, PEPCO, the electric utility serving Washington, DC, is working with DOE and GSA to cofund a multimillion dollar relighting project in Federal buildings.

Where available, utility rebate programs can be a useful supplement to Federal funds and staff. Not all utilities have programs, but for those that do, there is a wide range of programs reflecting the capacity and energy needs of the utility. Some utilities, recognizing the special budgetary, procurement, and other needs of governments, have created special marketing arms to work with them. For example, San Diego Gas and Electric Co. has an office solely for Federal, State, and local governments which helps them take advantage of rebates and engineering assistance offered by the utility to promote energy efficient technologies.[35]

Energy Performance Standards for New Federal Buildings

Under NECPA, all new Federal buildings are required to meet energy performance standards developed by DOE. The standard adopted for Federal buildings is similar to Standard 90-1-P developed by the American Society of Heating, Refrigerating, and Air-Conditioning Engineers (ASHRAE) and the Illumination Engineering Society.[36] The standard includes principles of building design for insulation and window design for building envelope, lighting, hot water, electric power distribution, HVAC system, and energy management.

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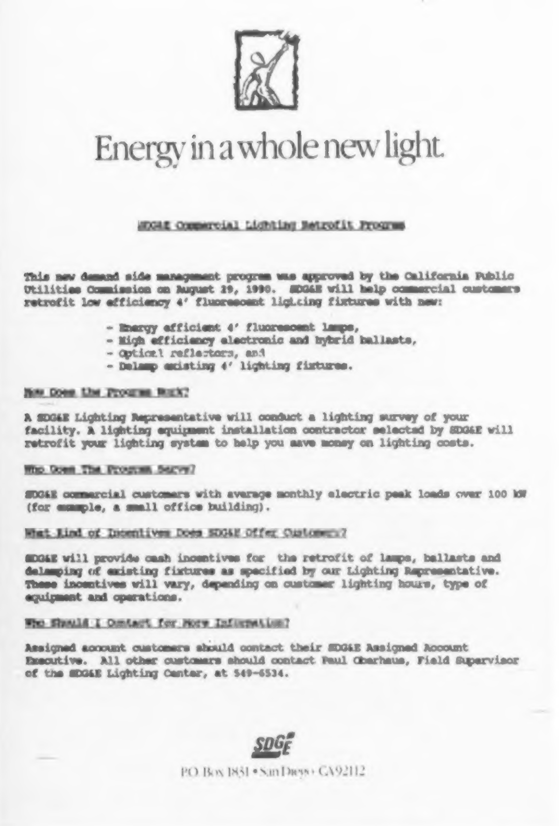
[32] There had been some uncertainty about whether Federal procurement policies allow facilities to accept utility rebates. That question was resolved for the General Services Administration by Public Law 101-509 Section 15, Nov. 5, 1990, and for the Department of Defense by the National Defense Authorization Act for Fiscal Year 1991, as discussed above. Those laws explicitly allow GSA and DOD to accept utility rebates.

[33] A forthcoming OTA report, "Prospects for Demand Management in Electric and Gas Utilities," is examining this type of program in detail.

[34] J.W. Currie, Pacific Northwest Laboratory, personal communication, February 1991.

[35] J.F. Drummer, Governmental Marketing & Services Manager, SDG&E, personal communication, Sept. 28, 1990. See United States Postal Service Case Study in ch. 5, which describes lighting rebates SDG&E granted to the San Diego Postal Division.

[36] U.S. Department of Energy, Federal Energy Management Program, *Federal Energy Management Activities*, "Federal Building Energy Conservation Standards," summer/fall 1990, pp. 21-22.



Energy in a whole new light.

SDG&E Commercial Lighting Retrofit Program

This new demand side management program was approved by the California Public Utilities Commission on August 29, 1990. SDG&E will help commercial customers retrofit low efficiency 4' fluorescent ligLcing fixtures with new:

- Energy efficient 4' fluorescent lamps,
- High efficiency electronic and hybrid ballasts,
- Optical reflectors, and
- Delamp existing 4' lighting fixtures.

How Does the Program Work?

A SDG&E Lighting Representative will conduct a lighting survey of your facility. A lighting equipment installation contractor selected by SDG&E will retrofit your lighting system to help you save money on lighting costs.

Who Does The Program Serve?

SDG&E commercial customers with average monthly electric peak loads over 100 kW (for example, a small office building).

What Kind of Incentives Does SDG&E Offer Customers?

SDG&E will provide cash incentives for the retrofit of lamps, ballasts and delamping of existing fixtures as specified by our Lighting Representative. These incentives will vary, depending on customer lighting hours, type of equipment and operations.

Who Should I Contact for More Information?

Assigned account customers should contact their SDG&E Assigned Account Executive. All other customers should contact Paul Oberhaus, Field Supervisor of the SDG&E Lighting Center, at 549-6534.

SDG&E

P.O. Box 1831 • San Diego • CA 92112

SDG&E
Retrofit Lighting Program
Investment Analysis

Company Name: U.S. Postal Service
Address: 3974 Sorrento Valley Blvd.
Job Number: 152

Retrofit savings (kWh)		
Lighting kWh—before	70,884	
Lighting kWh—after	24,984	
kWhr savings		45,900
Percent reduction		65%
Retrofit savings (dollars)		
kWh savings	45,900	
Cost/kWh	$0.100	
Lighting savings	$4,590	
Reduce A/C savings	$ 689	
Reduced maintenance	$ 333	
Total savings		$5,612
Cost		
Retrofit cost ( )estimate (X)final	$ 6,855	
SDG&E incentive	$ 5,331	
Customer cost		$ 1,524
Investment analysis		
Savings—3 years		$16,835
Annual return on investment		368%
Payback period		0.27

Additional benefits

- Hedge against future rate increases—possible increased future savings
- Brand new lighting system—reduced future maintenance cost
- More pleasing light—less lighting glare
- Additional profits for your business—or keeping your business more competitive
- Increases marketability of building

SDG&E's lighting rebate program announcement and an analysis performed for the U.S. Postal Service. Note that in this example, SDG&E is contributing over 75 percent of project costs, resulting in a very high return on investment for USPS.

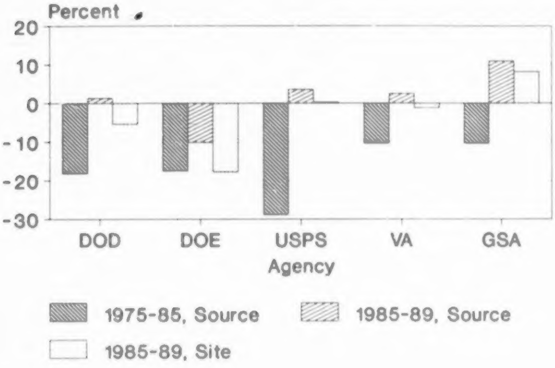
Energy Audits and Surveys of Existing Federal Buildings

In the 1970s, both Section 381 (a)(2) of EPCA and Section 547 of NECPA, as well as Order 12003, mandated that Federal agencies conduct audits of buildings larger than 5,000 square feet. Again in 1988, FEMIA directed DOE to conduct energy surveys of a sample of facilities throughout the government. Such audits form the basis for selecting retrofit measures that improve overall energy efficiency and minimize life-cycle cost, and for determining the potential for governmentwide energy and cost savings. However, results from the early energy audits were not compiled to assess total government potential, and there is no consolidated record of the extent to which the retrofits identified were implemented. Currently, some surveys are being conducted at Federal facilities, although those results have also not been coordinated to assess total government potential.

Key Agencies' Energy Management Plans

Primary responsibility for energy management lies with each Federal agency for its own facilities and operations. Under FEMIA, each major agency is required to develop and implement its own energy management plan to reduce building energy use per square foot by 10 percent by 1995. The following descriptions for the largest energy-using agencies demonstrate the diversity of approaches taken, reflecting the wide range of their missions and perceived opportunities. Also, the agencies' performance in meeting the 20 percent reduction goal

Figure 2-1—Percent Change in Building Energy Use per Square Foot, Fiscal Years 1975-85 and 1985-89



SOURCE: U.S. Department of Energy, "Annual Report on Federal Government Energy Management Fiscal Year 1985," DOE/CE-0171, August 1986, table 2, p. 6; and U.S. Department of Energy, "Annual Report to Congress on Federal Government Energy Management and Conservation Programs Fiscal Year 1989," Oct. 3, 1990, table 3, p. 15; and table F, p. 78.

for 1975-85[37] set forth in Order 12003 and performance between 1985 and 1989[38] are summarized (see figure 2-1). Note, annual reports have historically emphasized energy used at the source rather than energy used at the site as the most accurate measure (see footnote 13). However, in 1990, the 656 Committee and the Interagency Energy Management Task Force agreed to emphasize energy use at the site rather than at the source,[39] and presumably that will be the measure used to judge compliance with FEMIA's requirement of 10 percent savings between 1985 and 1995 although that is not certain. Accordingly, changes in energy between 1975 and 1985 are shown based on source accounting, and between 1985 and 1989 are shown based on both source and site accounting.

Department of Defense—Between 1975 and 1985, DOD reduced energy consumption per square foot in buildings by 18.1 percent, more than the average reduction accomplished by Federal agencies. Between 1985 and 1989, building energy use per square foot increased 1.4 percent using source accounting and declined by 5.4 percent using site accounting.

In 1986, DOD established a second 10-year plan to reduce energy consumption in buildings.[40] Under DOD's overall policy guidance, each service (e.g., Army, Navy, and Air Force) creates its own energy management plan with minimum interference. These plans, in turn, can be very detailed and comprehensive.[41] The overall DOD plan sets the services' minimum reduction goal, and assigns lead responsibilities with respect to research and development for energy conservation and conversion technologies to the three services. The assignment of lead service responsibilities, which helps reduce duplication of effort, has been given to the service with the most expertise in the relevant technology. For example, the Army is responsible for computer programs to determine building energy characteristics, energy-conserving structures and construction technology, advanced heating and air conditioning, and energy storage and distribution systems for fixed facilities.

On March 13, 1991, the Deputy Secretary of Defense set forth comprehensive new guidance for facility energy management, and established a goal of reducing energy use in all facilities by 20 percent in the year 2000 compared to 1985.[42]

Spending on energy conservation investments has decreased from $136 million in fiscal year 1985 to 0 in 1989. Reversing this trend, $10 million has been appropriated for fiscal year 1991, with a target of $50 million annually beginning in 1993.

Department of Energy—DOE is the largest consumer of energy in the civilian sector. Between 1975 and 1985, DOE reduced its buildings energy use per square foot by 17.5 percent. Between 1985 and 1989, DOE further reduced building energy use by 10.1 percent using source accounting, and by 17.7

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[37] U.S. Department of Energy, "Annual Report on Federal Government Energy Management Fiscal Year 1985," DOE/CE-0171, August 1986, table 2, p. 6.

[38] U.S. Department of Energy, "Annual Report to Congress on Federal Government Energy Management and Conservation Programs Fiscal Year 1989," Oct. 3, 1990, table F, p. 78, and table 3, p. 15.

[39] Tina Van Sickle, Federal Energy Management Program staff, personal communication, Mar. 20, 1991.

[40] U.S. Department of Defense, Office of the Assistant Secretary of Defense for Acquisition and Logistics, "Defense Energy Program Policy Memorandum 86-3," DEPPM 86-3, Apr. 16, 1986.

[41] See, for example, Reynolds, Smith & Hills, "Department of the Army Energy Resources Management Plan FY86-FY95," Department of the Army, January 1987.

[42] D.J. Atwood, Deputy Secretary of Defense, memorandum to secretaries of the military departments, Mar. 13, 1991.

Photo credit: Robin Roy

GSA's Suitland Complex has successfully used occupancy sensors to automatically turn off lights when not needed.

percent using site accounting, already beating the 1995 FEMIA goal.

In 1985, DOE established the Ten-Year In-house Energy Management Plan[43] with the goals of reducing energy consumption in buildings, metered processes, and vehicles and equipment by 10 percent by 1995 compared to fiscal year 1985. The plan consists of 12 programs that train employees in energy-related matters and alter procedures to include conservation elements. An example of employee training is within the central plant improvement program, which consists of all activities to make existing and new central heating and cooling plants more energy efficient. In 1983, a formal boiler operator training and tuneup program was established. The program consists of 4 days of classroom and hands-on training on boiler tuneups, and the identification of retrofit options. In fiscal year 1984, a steam-trap program was added. In the fiscal year 1989 annual report on in-house energy management, DOE stated that six training sessions were conducted and, assuming that all recommendations were implemented, the anticipated annual savings would be over $7 million.[44]

Several of the programs alter procedures to incorporate energy conservation decisions. An Operator Contractor Clause requiring efficient energy use has been added for DOE owned and leased facilities. The utility contract improvement program seeks to identify and promote integrated usage and cost reduction initiatives including conservation, load management, and generation techniques in concert with existing utility rate structure in order to meet total energy requirements at lowest possible cost. The metering program seeks to establish usage patterns to pinpoint conservation opportunities by monitoring actual consumption. New DOE buildings, owned or leased, are required to have permanent metering for each type of energy consumed.

Department of Veterans Affairs (VA)—Between 1975 and 1985, VA reduced buildings energy use per square foot by 10.4 percent. Between 1985 and 1989, use increased by 2.5 percent using source accounting, and declined by 1.1 percent using site accounting. VA delegates responsibility for energy management to its 162 medical facilities.[45] Each is required to create the 10-percent reduction plan for its facility. The central office monitors energy consumption quarterly and tracks facility progress toward meeting its goal.

The U.S. Postal Service (USPS)—Between 1975 and 1985, USPS exceeded the 20 percent energy reduction goal, reducing consumption by 28.8 percent per square foot. However postal energy use is rising due to increased automation, increased mail volume, budget constraints, the relaxation of federal temperature settings, and the required increased ventilation mandated in the proposed ASHRAE standard regarding indoor air quality. Energy use per square foot in USPS facilities rose 3.6 percent by source accounting or by 0.3 percent using site accounting between 1985 and 1989. Each of the five postal regions has been assigned a target reduction to be met using energy surveys, employee awareness (including energy discussions at higher levels of management and SES training), and improved maintenance.

General Services Administration—Between 1975 and 1985, GSA reduced building energy use per square foot by 10.4 percent.[46] Between 1985 and 1989, building energy use per square foot increased by either 11 percent or by 8.2 percent, using source or site accounting.

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[43] U.S. Department of Energy, Office of Project and Facilities Management, "FY1989 Annual Report on In-house Energy Management," DOE/MA-0416P, July 1990.

[44] U.S. Department of Energy, Office of Project and Facilities Management, "FY 1989 Annual Report on In-House Energy Management," July 1990, p. 34.

[45] Rajinder P. Garg, Chief, Energy Management Division, Veterans Administration, personal communication, Sept. 6, 1990.

In-house, GSA has a comprehensive master plan to be implemented by each region. Created in 1990 by energy coordinators, the plan is entitled the 5 Point Energy Reduction Plan.[47] The five points are planning and monitoring, identifying and implementing projects, improving operations, raising energy awareness, and conserving energy in leased space. Each point contains a series of activities to be completed by a specific date and responsible office. The administration has set aside $30 million in its fiscal year 1991 budget to complete conservation projects.

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[46] The General Service Administration's performance between 1975 and 1985 is a good example of the effect of using source rather than site accounting in measuring building energy use. Measured according to site energy, GSA's building energy use declined by 24.5 percent rather than only 10.4 percent.

[47] General Services Administration, Real Property Management and Safety, "GSA 5 Point Energy Reduction Plan," March 1990.

Chapter 3

Federal Spending on Energy Used in Commercial and Residential Buildings

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Chapter 3

Federal Spending on Energy Used in Commercial and Residential Buildings

The Federal Government owns and leases about 500,000 buildings of various sizes, construction, and uses. In fiscal year 1989, the energy used in these buildings cost the U.S. Treasury about $3.5 billion. In addition, the Federal Government spends approximately $4 billion each year subsidizing the utility bills of about 9 million lower income households through various assistance programs. Much of the electricity, natural gas, and petroleum purchased with this combined $7.5 billion is inefficiently used. Although the responsible Federal agencies have not analyzed basic energy- and cost-saving opportunities in Federal facilities, apparently at least 25 percent of the energy could be saved using a wide variety of currently available, cost-effective measures. Similar opportunities appear to exist in subsidized households.

FEDERAL ENERGY USE IN COMMERCIAL BUILDINGS[1]

As of 1986[2] there were just over 4 million commercial buildings with 57 billion square feet of floor space in the United States. The main uses of these buildings are highly varied, including offices, retail shops, schools, and hospitals (see table 3-1a). The Federal Government owns over 51,000 of these commercial buildings with between 1 and 2 billion square feet of floor space,[3] and has about 7 percent additional floor space under lease.[4] As in the private sector, Federal building uses are diverse (see table 3-1b).

By far the largest Federal user of energy in commercial buildings is the Department of Defense (DOD), with about two-thirds of the total floor space. This does not include DOD's buildings in foreign countries. DOD commercial buildings include the complete range of functions: offices, warehouses, hospitals, retail stores, cafeterias, churches, etc. Figure 3-1 shows facilities energy use by the main Federal energy-using departments.

Federal agencies own most of the commercial building space they occupy. However, Federal agencies also often lease space either from private companies or from the General Services Administration (GSA), which owns and leases commercial space on their behalf. Because GSA often manages property for other agencies, it is the third largest owner (after DOD and the U.S. Postal Service (USPS)) of Federal buildings.

Enormous amounts of energy in several forms are used just to make the buildings inhabitable, that is, to provide light, heat, ventilation, and air conditioning. Large amounts of additional energy are used to power the wide assortment of appliances and equipment used in the buildings, ranging from computers to conveyor belts to stoves. In total, $61 billion in electricity, natural gas, fuel oil, district heat, and propane were consumed in 1986 to operate the Nation's commercial buildings.[5] Federally owned and occupied nonresidential buildings accounted for over 6 percent of that total.[6]

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[1] Defined according to the Energy Information Administration's Nonresidential Buildings Energy Consumption Survey as: "roofed and walled structures used predominantly for a nonresidential, nonagricultural, and nonindustrial purposes and larger than 1000 square feet." U.S. Department of Energy, Energy Information Administration, *Nonresidential Buildings Energy Consumption Survey: Characteristics of Commercial Buildings 1986*, DOE/EIA-0246 (Washington, DC: U.S. Government Printing Office, September 1988), p. 3.

[2] The year 1986 is the most recent for which data are available. However, each year approximately 100,000 new commercial buildings are constructed. Ibid., p. 82.

[3] Ibid., table 25, p. 79 reports about 1.1 billion square feet in its survey; U.S. General Services Administration, "Inventory Report of Real Property Owned by the United States Throughout the World," p. 11, Sept. 30, 1989, reports about 1.9 billion square feet in the United States.

[4] From U.S. General Services Administration, "Inventory Report on Real Property Leased to the United States Throughout the World," 1989. That report does not distinguish between residential and nonresidential uses, nor does it note building size.

[5] U.S. Energy Information Administration, "Nonresidential Buildings Energy Consumption Survey: Commercial Buildings Consumption and Expenditures 1986," DOE/EIA 0318(86), table 1, May 1989, p. 4.

[6] Total spending on energy for all federally owned buildings was $4 billion in fiscal year 1987, according to U.S. Department of Energy, Assistant Secretary, Conservation and Renewable Energy, "Annual Report on Federal Government Energy Management Fiscal Year 1987." Around $200 million of that was in military family housing. An additional amount was spent on energy used in leased buildings for which the Federal Government does not pay utilities directly.

Table 3-1a—Commercial Buildings in the United States

	All buildings	
Building activity	Number of buildings (1,000)	Total floor space (million sq. ft.)
Assembly	571	7,287
Education	240	7,200
Food sales	102	712
Food service	201	1,277
Health care	51	2,104
Lodging	137	2,785
Mercantile/service	1,273	12,710
Office	607	9,499
Public safety	50	665
Warehouse	487	8,540
Other	94	3,730
Total	3,813	56,508

SOURCE: U.S. Department of Energy, Energy Information Administration, "Commercial Buildings Consumption and Expenditures 1986," DOE/EIA-0318(86), May 1989, p. 9.

Table 3-1b—Federal Buildings in the United States

	Total floor space (million sq. ft.)
Service	431
Office	510
Research and development	124
Industrial	123
Hospitals	131
Storage	462
Schools	122
Other	103
Housing	705

SOURCE: U.S. General Services Administration, "Summary Report of Real Property Owned by the United States Throughout the World as of September 30, 1988," GSA Public Buildings Service.

Electricity Use

Electricity is the dominant energy form used in commercial buildings in terms of total annual spending ($47 billion in 1986, $2 billion of which is Federal).[7] Electricity is essential for powering lights, electronic equipment, and the wide array of motors found in everything from elevators to conveyor belts to heating, ventilating, and air-conditioning (HVAC) equipment, and is also used for heating and cooking. It is also the most expensive per unit of energy delivered to the Federal Government (at $17/million Btu, electricity is four times more costly than natural gas).

Precisely how is electricity used in Federal commercial buildings? Although a large body of information is available, the amount of electricity actually used in any given building for any function such as lighting or office equipment can be only approximated since individual appliances or devices are not individually metered. Buildings typically have a single meter tracking the total amount of electricity being used by all devices. Some Federal facilities such as military bases and other multibuilding complexes have even less information available. These facilities may have only a few meters monitoring energy use for a facility with hundreds or thousands of buildings. The lack of detailed information about energy use in Federal buildings is a frequently cited impediment to the analyses and programs needed to implement cost-saving efficiency measures.

Due to the wide variety of building uses, geographic and weather conditions, type and age of construction, maintenance histories, and other factors, the amount of energy used in different buildings is highly variable. As weather conditions change from year to year, HVAC demand can change significantly. This complicates efforts to identify and monitor the performance of widely applicable energy- and cost-saving measures. It also complicates efforts to set standards of performance, such as maximum energy use per square foot, and to compare buildings. Each building has unique energy-use patterns and cost-saving opportunities.

Despite the limitations on detailed or site-specific information, there are some general estimates of the relative consumption of different uses. Lighting and air conditioning are the largest overall uses of commercial building electricity, although estimates vary. For example, one Electric Power Research Institute (EPRI) study estimated that lighting and cooling, respectively, consume 41 percent (since revised to 34 percent) and 31 percent of commercial building electricity.[8] As should be expected, the study's estimates varied greatly by building type; for example, hotels were estimated to use only 23 percent of their electricity for lighting, with 43 percent used for cooling. Reflecting the uncertainty inherent in determining detailed energy uses, other

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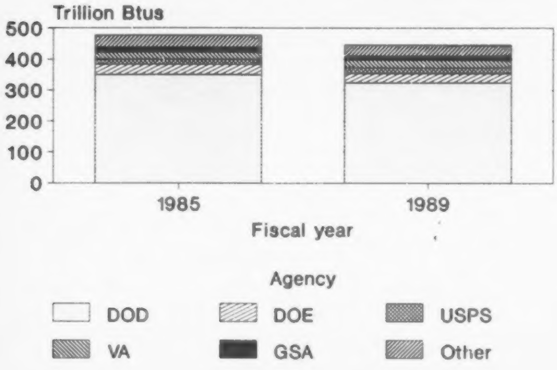
[7] U.S. Energy Information Administration, op. cit., footnote 5.

[8] Georgia Institute of Technology, *The Commend Planning System: National and Regional Data and Analysis*, EPRI EM-4486 (Palo Alto, CA: Electric Power Research Institute, March 1986), p. B-37. Current best estimate of 34 percent for lighting from letter from Clark Gellings, Electric Power Research Institute, Feb. 15, 1991.

Figure 3-1—Federal Facilities Energy Use



NOTE: Site accounting used for electricity (see ch. 2).

SOURCE: U.S. Department of Energy, Federal Energy Management Program, "Report on Federal Government Energy Management and Conservation Programs," October 1990.

studies have produced quite different estimates. For example, a Gas Research Institute (GRI) study estimated that only 26 percent of electricity used in buildings is for lighting (11 percent in hotels), far less than EPRI's current estimate of 34 percent.[9] However, both studies agree that lighting and HVAC together account for over 70 percent of total commercial building electricity use.

Natural Gas

Natural gas is the second most heavily used energy source in the Nation's commercial buildings. It is the dominant energy source for space heating, water heating, and cooking, and accounted for $8.4 billion in 1986.[10] The Federal share of this spending was around $0.5 billion. As in the case with electricity, no one knows precisely how much natural gas is consumed in different uses. However, fewer devices use natural gas, so both metering and estimating use are less complicated. GRI estimates that space heating alone accounts for over two-thirds of gas use in commercial buildings, with under 4 percent used for water heating. The remainder is consumed in miscellaneous uses including cooking and cooling.

Fuel Oil and Miscellaneous

Fuel oil is used in just 12 percent of commercial buildings, mainly for space heating, with a total bill of $2 billion. A disproportionately large share, 25 percent or 17.4 million barrels/year, of that total is used in Federal facilities. The fuel oil is used almost entirely for space heating.

Some of the Nation's largest buildings use district heat (e.g., steam or hot water generated in a central plant and distributed to a number of buildings) for space heating, water heating, and cooking, with a total bill of $2.6 billion. There is also some use of district cooling. Federal buildings use a disproportionately large amount of district heat relative to other buildings. This is consistent with the high level of oil use, and reflects the use of fuel oil to generate steam for district heating systems. The remaining energy forms (e.g., propane and wood) are far less common and used mainly for space heating.

FEDERAL SPENDING ON RESIDENTIAL ENERGY USE

As of 1989 there were over 90 million households for about 240 million people in the United States.[11] The Federal Government subsidizes or pays part or all of the utility bills in about 9 million of these households. Two executive agencies are responsible for the vast majority of Federal expenditures on residential energy use: the Departments of Housing and Urban Development (HUD) and Health and Human Services (HHS). These two agencies subsidize or provide assistance payments for residential utility bills for low-income Americans. In addition, DOD houses 1.4 million military personnel and their dependents in family housing, and a few other agencies have a few thousand residences.

In total, $98 billion in electricity, natural gas, fuel oil, district heat, and propane were consumed in the Nation's homes in 1987 to operate appliances and

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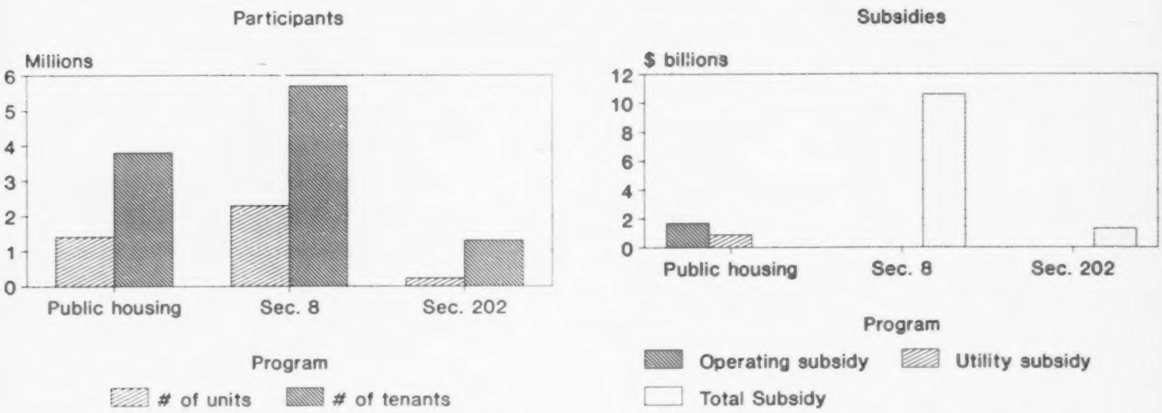
[9] Gas Research Institute, *Baseline Projection Data Book* (Washington, DC: 1989), p. 122.

[10] U.S. Department of Energy Information Administration, op. cit., footnote 5, table 2, p. 5-6.

[11] This population estimate does not include the homeless and people living in institutions (e.g., military barracks, prisons). U.S. Bureau of the Census, *Statistical Abstract of the United States: 1990*, 110th ed. (Washington, DC: 1990), pp. 2, 45.

Figure 3-2—HUD-Assisted Housing Participants and Subsidies, 1989



SOURCE: U.S. Department of Housing and Urban Development.

provide hot water, heating, and cooling.[12] In 1989, the Federal Government's share of housing energy costs was about $4 billion.

Housing and Urban Development

Each year, HUD spends from $2 to $3 billion subsidizing the energy bills for 3.6 million federally assisted housing units (see figure 3-2).[13] There are two main HUD-assisted housing programs: a low-income public housing program and the Section 8[14] rental housing assistance program which can be used in privately owned housing.[15] Both programs are administered by HUD-regulated local public housing authorities (PHAs), of which there are about 2,700 nationwide.

Public Housing

Under the public housing program, local public housing authorities and Indian housing authorities develop, own, and manage housing projects. They receive HUD subsidies for construction, rehabilitation, and operating costs. Currently, approximately 1.4 million housing units in nearly 10,000 individual projects are administered by 2,700 PHAs. In total, about 3.8 million people live in public housing.

Energy expenditures constitute a large fraction of HUD's total spending on public housing. HUD's payment subsidy for utilities in these units for fiscal year 1989 was over $900 million (most was for energy, but this figure also includes water and sewer).[16]

Tenants of public housing typically pay 30 percent of their adjusted family income toward rent plus utilities, with the remainder of costs paid for by the housing authority (which is reimbursed by HUD). HUD does not keep account of the *total* annual spending on utilities including both HUD and tenant copayments.

Section 8

HUD's Section 8 low-income assistance program subsidizes 2.3 million housing units. Unlike public housing, Section 8 housing may be privately owned. Through the Section 8 program, HUD subsidizes total housing costs, including both rent and utilities

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[12] The year 1987 is the most recent for which detailed data are available for residential energy use. However, each year over 1 million new households are added to the existing stock. U.S. Department of Energy, Energy Information Agency, *Household Energy Consumption and Expenditures 1987 Part 1: National Data*, DOE/EIA 0321/1(87) (Washington, DC: U.S. Government Printing Office, October 1989), table ES1, p. viii.

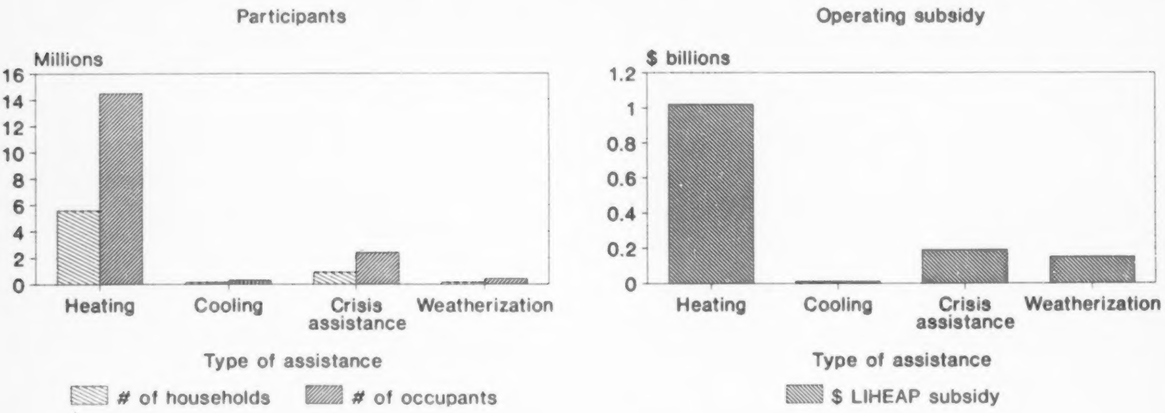
[13] J.M. MacDonald et al., *Existing Building Efficiency Research, 1987-1988*, Oak Ridge National Laboratory, ORNL/CON-268 (Washington, DC: U.S. Government Printing Office, August 1988), p. 25.

[14] Section 8 from the United States Housing Act of 1937, as amended (42 U.S.C. 1437f) (1990, Cumulative Annual Pocket Part).

[15] For a historical overview of HUD-assisted-housing programs, see Grace Milgram, Library of Congress, Congressional Research Service, *Housing Policy: Low-and Moderate-Income*, IB88106 (Washington, DC: Congressional Research Service, Aug. 29, 1990).

[16] John Comerford, U.S. Department of Housing and Urban Development, personal communication, Oct. 17, 1990.

Figure 3-3—HHS-Assisted Housing Participants and Operating Subsidies, Fiscal Year 1989



SOURCE: Number of occupants based on average household size in the United States. U.S. Department of Health and Human Services, Office of Energy Assistance, "Low Income Home Energy Assistance Program Report to Congress for FY 1989," October 1990.

for low-income, elderly, or handicapped tenants of participating rental properties. HUD subsidizes the difference between "fair market rent" (including utility expenses) and 30 percent of tenant adjusted income.

HUD does not keep track of energy use and spending in Section 8-assisted housing. As a result, less is known about the cost of energy in Section 8 housing compared to the public housing program. However, based on the amount of energy spending in public housing ($650/unit annually), a reasonable estimate of annual Section 8 subsidies which are used for energy is $1.5 billion. As with public housing, this estimate does not include the amount paid for by tenants.

Health and Human Services[17]

HHS' Low Income Home Energy Assistance Program (LIHEAP)[18] assists low-income households in meeting costs of residential heating or cooling. Some LIHEAP recipients live in HUD-assisted housing, but the majority do not. HHS provides grants to the States and to Indian tribes and territories which administer the program. In fiscal year 1989, HHS spending on LIHEAP totaled $1.4 billion. States supplemented this amount with oil overcharge funds ($174 million), LIHEAP carryovers from fiscal year 1988 ($82 million), and a small amount of State funds ($6 million). In total, around 15 million[19] people in about 6 million households were assisted with heating and cooling subsidies (see figure 3-3). The 6 million households receiving LIHEAP assistance represent only around 23 percent of those eligible under the Federal maximum income standard. That is, over 25 million households meet the Federal maximum income standard for LIHEAP assistance. States often apply more restrictive standards.

LIHEAP assistance covers some but not all of the total cost of a recipient's energy use for heating and cooling. For example, approximately 50 percent of a typical recipient's heating costs are paid by LIHEAP, with the remainder paid by the recipient or other sources. Twenty-one percent or about 1.3 million LIHEAP households live in HUD-assisted housing, so they receive energy subsidies or assistance from both HUD and HHS.

Until 1994, States are also allowed to divert 10 percent of LIHEAP funds to nonenergy block grants such as social services, community services, and alcohol, drug abuse, and mental health services. In fiscal year 1989, 28 States did so, most of them to the maximum amount, reducing the total spending on energy assistance.

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[17] This section is based on information contained in U.S. Department of Health and Human Services, Office of Energy Assistance, "Low Income Home Energy Assistance Program Report to Congress for FY 1989," October 1990.

[18] The Low Income Home Energy Assistance Program is authorized by Title XXVI of the Omnibus Budget Reconciliation Act of 1981 (OBRA), Public Law 97-35, as amended.

[19] HHS does not track the number of people assisted by LIHEAP. This estimate is based on average household size in the United States.

The majority of LIHEAP recipients use natural gas as their primary heating source, with fuel oil and electricity far below. Compared to all U.S. households, LIHEAP recipients use far less electric heating and more liquefied petroleum gas (LPG) and kerosene (see figure 3-4).

Department of Defense

DOD houses over 1.4 million military personnel and their dependents in 422,000 multifamily and single family housing units worldwide (see figure 3-5). Most reside in the United States, but large concentrations are in several other countries. The U.S. Army, largest of the services, has just under half the total housing units and just over half of the total served population. In addition to family housing, military barracks house a large number of troops which are not included in these totals.

Generally, energy used in individual units is neither separately metered nor charged for. Total energy use in military housing is around 53 billion MBtus annually. This energy cost the Federal Government around $200 million based on the average cost of energy.

Main Energy Uses in Federally Owned or Assisted Housing[20]

As in the commercial sector, only a few main energy uses constitute the majority of residential energy consumption and spending (see figure 3-6). **By far the highest on the list both in terms of total energy use and spending is space heating.** Heating energy use and expenditures vary greatly depending on factors such as climate, type of building, size of household, and condition. For example, an average household in west coast States spends one-third as much on heating as a New England household, and an average single family household spends twice the amount on heating as one in a large apartment building. As an indication of increased energy efficiency in construction over time, homes built since 1980 use only two-thirds the energy of homes built before 1950, after adjusting for weather and home size. Natural gas supplies over two-thirds of the energy used for space heating. Most of the rest (20 percent) is provided by fuel oil and kerosene, with the remainder split between electricity and LPG (5 percent each).

Nearly every household has a water heater, which on average consumes 18 MBtu/year, making that the next largest residential energy use. As with space heating, natural gas provides two-thirds of the energy used in water heaters. Some large apartment complexes (common among assisted housing projects and some military housing) may have a central boiler providing water heating and/or space heating.

Refrigerators are the largest single use of residential electricity, consuming about 20 percent of the total. Nearly every household has a refrigerator, and on average, it consumes around 1,500 kWh/year. Air conditioning is the second largest residential electricity use after refrigerators. Unlike refrigerator use, energy use for air conditioning depends strongly on household location and type. For example, only a third of households in the relatively cool Northeast even have air conditioning, compared to 80 percent in the South.[21] And those air conditioning units in the South consume on average more than double the amount used in units in the Northeast. Air conditioning depends strongly on income levels. Households below the poverty line are a third less likely to have air conditioning than the average household. A large list of other uses constitute the remaining 16 percent of household energy. These include cooking, dishwashers, clothes washing and drying, lighting, and electronic equipment such as televisions.

As in the case with U.S. housing generally, energy use in federally assisted and owned households is diverse, reflecting the diverse nature of the building stock and weather conditions across the country.[22] There are many building styles in public housing projects, ranging from high-rise apartments to low-rise apartments to groups of two- or three-story duplexes. Large projects may have several hundred units. Age and condition of public housing varies widely, too. Many projects were constructed prior to

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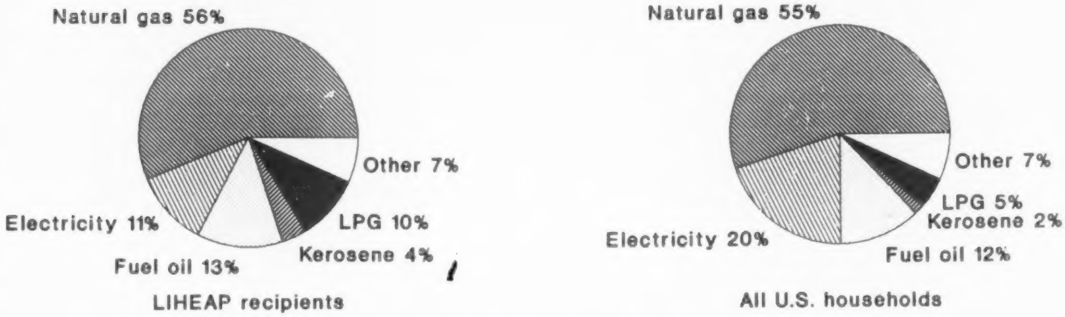
[20] The information in this section is derived from, op. cit., footnote 12. The descriptions here are true of housing in general, although federally owned or assisted households have some different attributes.

[21] U.S. Department of Energy, Energy Information Administration, op. cit., footnote 12, tables 7, 32, ES1, October 1989.

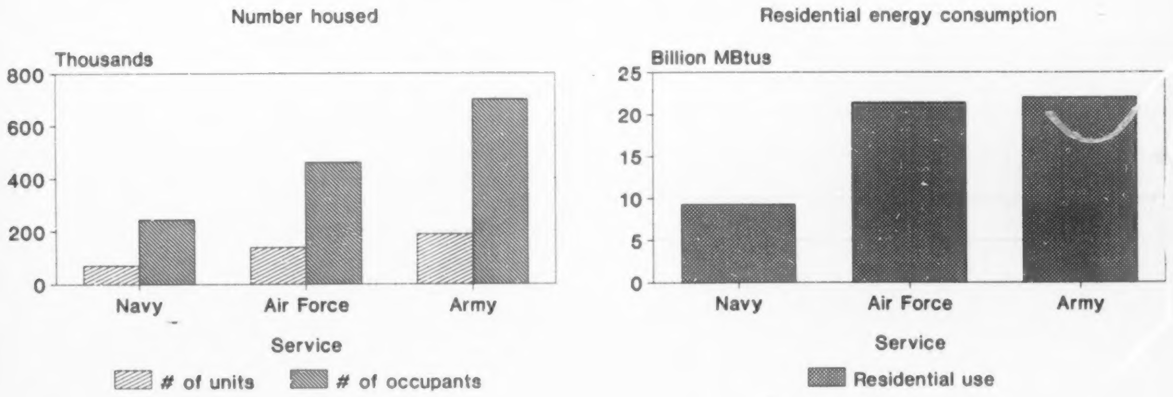
[22] See Perkins & Will and Ehrenkrantz Group, "An Evaluation of the Physical Condition of Public Housing Stock, Vol. 4," HUD Report H2850, 1980.

Figure 3-4—Primary Heating Source, LIHEAP Households and All U.S. Households, 1989



SOURCE: U.S. Department of Health and Human Services, Office of Energy Assistance, "Low Income Home Energy Assistance Program Report to Congress for FY 1989," October 1990.

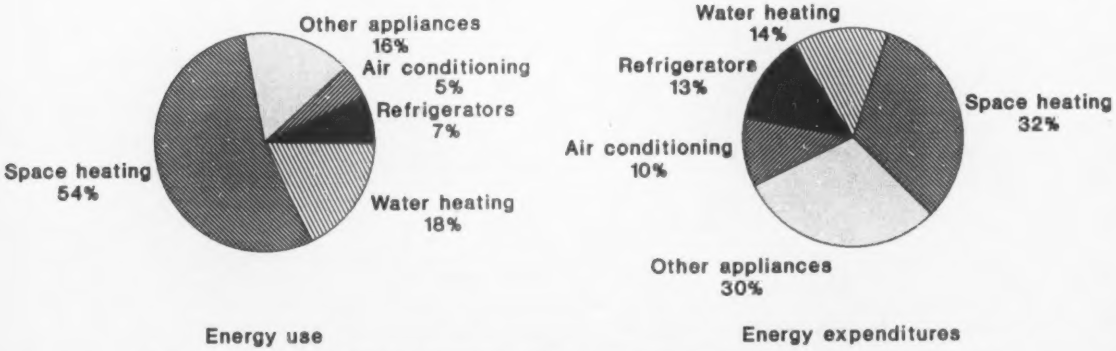
Figure 3-5—Military Family Housing, 1989



NOTE: Source accounting used for electricity.

SOURCE: U.S. Department of Defense.

Figure 3-6—Residential Energy Use and Expenditures, 1987



SOURCE: U.S. Department of Energy, Energy Information Administration, "Household Energy Consumption 1987," DOE/EIA-0321/1(87) (Washington, DC: U.S. Government Printing Office, October 1989).

the first oil-price shock in 1973, and were built with accordingly low insulation levels. HHS-assisted and military households have a similar broad range, with the addition of single family houses. Even within a given complex, units can have widely varying energy use. For example, an end unit in an apartment building, with more exposed walls and windows, may require considerably more fuel for heating than an interior unit. Similarly, the same unit with different occupancy levels can have different energy use.

HOW MUCH CAN THE FEDERAL GOVERNMENT TRIM FROM ITS BUILDING ENERGY BUDGETS?

Federally Owned and Leased Buildings

There is little question that a large fraction of the Federal Government's $3.5 billion direct annual spending on energy in its buildings could be greatly reduced using cost-effective, well-proven technologies. For example, at the five federally owned or leased facilities in OTA's commercial case studies (see "Chapter 5: Case Studies"), the facility managers estimated that an average savings of at least 25 percent in annual operating cost and energy use appears achievable with proven and highly cost-effective technology. This level of saving requires no change in occupant comfort or productivity; rather, it involves more effective use of energy, either through more efficient equipment or through improved operations and maintenance practices.

OTA's case study estimates included only highly cost-effective options in which the capital costs and other costs of implementation are small compared to the savings, with simple paybacks of under 3 years. A less stringent economic test which is more consistent with the cost of capital in the United States would likely produce considerably higher estimates. For example, the 3 year payback represents a long-term return on investment of about 30 percent, far higher than the average rate of return on electric utility investments (about 14 percent in 1991) or the Treasury's cost of funds (currently under 8 percent).

Several recent analyses of the potential for energy efficiency in commercial buildings in the United States have estimated that gains of 25 percent or more are technically and economically feasible.[23] While these analyses do not focus on Federal facilities, they are indicative of the potential for typical buildings. Whether Federal facilities offer more or fewer opportunities for improvement is speculative.

The Federal Energy Management Program has not developed estimates either of the government's potential energy and cost savings nor of the capital and other resources required to attain those savings. Similarly, none of the individual energy-using Federal agencies contacted by OTA have produced estimates for their own facilities. All cite difficulties of performing the information collection and analyses required for even approximate estimates. Although building audits mandated under the Energy Conservation Policy Act were conducted at most major facilities in the past decade, there has been no Federal effort to compile the results, much less to keep results current. The same is true of the facility energy surveys mandated under the Federal Energy Management Improvement Act of 1988.

The lack of reasonably detailed, comprehensive analytical effort to date should not be interpreted as representing a lack of energy efficiency opportunities. Although Federal agencies have not published overall estimates of prospects for efficiency gains, they often take the public position that large gains are possible.[24] It is important to note that **many easy, low risk (or risk-free) energy- and cost-saving measures with excellent economic characteristics have yet to be implemented at Federal facilities.** The best options currently available appear to be excellent ways to reduce costs, energy, and environmental impacts under virtually any set of reasonable assumptions of future energy prices.

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[23] For example, see R.S. Carlsmith et al., "Energy Efficiency: How Far Can We Go?" ORNL/TM-11441, Oak Ridge National Laboratory, Oak Ridge, TN, January 1990; and Barakat & Chamberlin, Inc., "Efficient Electricity Use: Estimates of Maximum Energy Savings," EPRI CU-6746, Electric Power Research Institute, March 1990; and Committee on Alternative Energy Research and Development Strategies, National Research Council, *Confronting Climate Change: Strategies for Energy Research and Development*, DOE/EH189027P-H1 (Washington, DC, August 1990), pp. 80-90.

[24] For example, see U.S. Department of Energy, Federal Energy Management Program, "Annual Report on Federal Government Energy Management and Conservation Programs Fiscal Year 1989," Oct. 3, 1990, p. 26-41; and Executive Order 12759, signed Apr. 17, 1991, which includes a provision for a 20-percent reduction in both buildings and industrial facilities by 2000.

Federally Assisted Households

As in the case with the Federal Government's commercial buildings, **there seems little question that increased use of existing, proven technologies would reduce a large fraction of the $4 billion in residential energy paid for by the government in federally owned and assisted households.** These gains require no change in occupant comfort. For example, a program of early refrigerator retirement coupled with using the most efficient models available offers the prospect of reducing Federal residential electricity expenditures by a few percent. Such an early retirement program for other appliances such as water heaters and washing machines could also cost-effectively save both gas and electricity. These energy- and cost-saving appliance opportunities exist in all types of federally owned and assisted households.

Since space heating is the leading residential energy use, many opportunities for energy and cost savings depend on promoting higher efficiency heating equipment and weatherization programs. Opportunities for savings are large. For example, a comprehensive study of energy-saving opportunities in public housing published by HUD in 1988 estimated the potential for over 30-percent savings with an average payback of 4.5 years for capital invested.[25] These results were consistent with a study performed a decade earlier.[26] OTA's case study of one public housing authority found that at least 30-percent gains could be realized using highly cost-effective measures such as weatherstripping and insulation. Several field studies of program implementation have verified that large savings are possible, although the performance in different projects has been highly variable.

Results of field studies of low-income weatherization programs (e.g., those funded by HHS and DOE) have found considerable savings potential, although results are variable.[27] To gain a better understanding of the potential gains and best methods to use, DOE's Weatherization Assistance Program recently began a comprehensive 3-year, $5-million review of performance. This analysis should help identify the economically and technically most effective programs for the future. HHS has not analyzed the effectiveness of LIHEAP weatherization funds in reducing energy use and reducing the future need for LIHEAP funding, but is providing input to DOE's Weatherization Assistance Program study. Analyses of the relative merits of energy assistance and weatherization assistance have been largely left to the individual States which administer the HHS funds.

Although weatherization and rehabilitation programs have been promoted in federally assisted households, much remains to be done. For example, HUD's 1988 study of modernization needs found that the total one-time investment required to bring properties up to minimum standards and "enhance their long-term viability" (including safety, health, and environmental improvements as well as energy) amounted to over $20 billion.[28] However, annual spending on modernization has been only $1.6 billion during the past several years.[29] Similarly, each year less than 1 percent of the low-income households eligible for LIHEAP utility payments are weatherized under either LIHEAP or DOE's weatherization assistance programs.

It is difficult to estimate total spending on energy efficiency at HUD: funds spent on general rehabilitation often include some energy measures but are not listed as energy efficiency efforts. For example, double-pane insulated windows may be used when replacing broken single-pane windows. The result is considerable improvement in the building's resistance to heat loss, but may not be noted as an energy upgrade. Similarly, repair of flat roofs may be accompanied by added insulation. Because the primary reason for an energy efficiency upgrade may be basic maintenance, keeping track of spending and implementation of efficiency measures is complicated.

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[25] The study identified capital improvements and repairs, such as fixing windows and upgrading HVAC equipment, costing $939 million which would save $211 million annually. In addition, window repairs and improved operation and maintenance practices costing $98 million and needing to be repeated every 3 to 5 years would save $112 million annually. These Operations & Maintenance practices include weatherstripping and caulking. Abt Associates, "Study of the Modernization Needs of the Public and Indian Housing Stock," HUD-1130-PDR, March 1988, pp. 83-84. Note that HUD's total annual utility spending for public housing is around $900 million, as described previously.

[26] Perkins & Will and Ehrenkrantz Group, op. cit., footnote 22.

[27] See for example, many of the articles in *Proceedings from the ACEEE 1990 Summer Study on Energy Efficiency in Buildings* (Washington, DC: American Council for an Energy-Efficient Economy, 1990), vol. 1 to 10.

[28] Abt Associates, op. cit., footnote 25.

[29] U.S. Housing and Urban Development, "Programs of HUD 1989-1990," HUD-214-PA(17), October 1989, p. 75.

ENERGY- AND COST-SAVING MEASURES: ARE THEY TRULY WORKING OPTIONS FOR THE FEDERAL GOVERNMENT?

For nearly every application of energy in residential and commercial buildings, measures are available that can improve the efficiency of use.[30] Many, but certainly not all, have attractive cost and performance characteristics. Deciding which measures to pursue, if any, often requires careful engineering and economic analyses. Successful programs, those which reduce energy use and overall costs, also often require ongoing, dedicated efforts to ensure that they work initially and continue to work. This section examines some of the useful lessons from the past decade of energy efficiency programs.

There Are Many Effective Energy Efficiency Measures

The variety of currently available efficiency measures and the range of economic and performance characteristics is large. **Many currently available measures appear to have excellent economic and performance characteristics and have been proven in use, although they are not yet standard practice.** There is a large and growing body of applied research into the performance of a variety of energy efficiency programs.[31] There is also a large body of less formal information in trade journals which report on the results of efficiency measures.[32] These report on a continuing stream of successful energy management efforts following a wide range of approaches.

New Technologies Do Not Always Work as Planned

After many years of energy efficiency efforts throughout the U.S. economy, including within the Federal Government, it is clear that energy efficiency programs can work well. It is also clear that some energy efficiency technologies and programs have not always performed as well as expected. Both research and trade journals report a steady stream of projects performing below expectations. (They also show a steady stream of projects which perform excellently.) Sometimes new technology does not perform as it should, as in the case of the excessive failure rate of some early electronic ballasts. As a corollary, technologies are continually being improved and refined, or disappear from the market. Again, electronic ballasts provide an example with the high reliability they now have demonstrated.

As with any evolving technology (and as with many well-established technologies), some products have marginal to poor performance and economics but have yet to be driven off the market. Naturally, this greatly complicates the job of facility managers in implementing cost- and energy-saving technologies.

Also, because of the wide variety of buildings, uses, technologies, and other conditions, it is also possible that good technologies can be misapplied, resulting in poor performance or unmet economic expectations.[33] For example, because compact fluorescent lamps are larger and heavier than the incandescent lamps they replace, there are many light fixtures in which they cannot be used. Also, although the color of light produced is good, it is not identical to incandescent light. A program to replace all incandescent lamps in a building with compact fluorescents which neglects those facts could produce considerable dissatisfaction.

Savings Estimates Often Differ From Actual Savings

Estimates of potential savings are important for program planning, but the aim of energy management programs is to realize actual reductions in energy use and overall costs. Analyses of past energy efficiency programs have often found that savings were less than expected, sometimes by large amounts. There are many reasons. Sometimes technologies simply do not perform as planned. Savings estimates are often based on idealized engineering analyses which may be distinctly different from conditions found in practice. Generally, measuring the actual impact of a conservation measure is difficult due to the lack of detailed energy use metering and the variability in use resulting from weather and occupancy changes.

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[30] An ongoing OTA study, "Residential and Commercial Energy Efficiency," is examining the difference between estimates and actual results in-depth.

[31] See for example, U.S. Department of Energy, *Buildings Energy Technology*, any issue; or *Proceedings from the ACEEE Summer Study on Energy Efficiency in Buildings* (Washington, DC: American Council for an Energy-Efficient Economy), Biennial, any issue.

[32] See, for example, any issue of *Energy User News*, published monthly.

[33] One example of a publication which has detailed articles about a wide range of energy-savings opportunities in actual use is *Energy User News*, published monthly. The real world, site-specific information presented there can be of great use in reducing the risk of using new energy efficiency measures.

Applicability of Efficiency Measures Is Often Site-Specific

Some energy- and cost-saving measures are generally good practice and should be widely applied, requiring relatively simple engineering or economic analysis. For example, use of motion detectors to control lights in occasionally used spaces such as restrooms, conference rooms, and private offices makes economic sense and performs well in most such circumstances. Eventually, use of these approaches may become the rule rather than the exception that they currently are. Another example is the apparently cost-effective and reliable combination of high efficiency electronic ballasts coupled with fluorescent "T-8" tubes.

Other measures have highly site-specific economic and performance characteristics, requiring fairly detailed engineering and economic analyses. For example, the benefits of adding an energy management system depend on the type of heating, ventilating, and air conditioning equipment in place (and possible plans to replace existing equipment), as well as the building's schedule, external characteristics and internal layout and occupancy. Similarly, opportunities to delamp, or reduce lighting in overlit areas, can only be determined from a site survey which evaluates current lighting levels and the levels which would result after delamping. **While the applicability of these measures is site-specific, conducting site surveys including engineering and economic analyses to identify candidate measures followed by funding, staffing, and implementation should be a reasonable general practice.** To realize the potential cost and energy savings, the site survey would have to be followed by detailed audits and implementation where indicated.[34]

The desirability of any measure depends on several factors including the performance, initial cost, operating costs or cost savings, environmental impacts, and risk. All measures cost something but some, such as performing preventive maintenance on steam traps are nearly free, are well-proven (thus entail little technical risk), and can generate considerable savings. Other measures, such as replacing existing low efficiency light fixtures and lamps with high efficiency systems, may involve a capital expenditure which is rapidly paid back through reduced operating costs. Still other measures, such as the early retirement and replacement of a moderately efficient air conditioner with a more efficient but commercially unproven unit, may or may not pay back.

Successful Implementation Often Requires Ongoing Effort

Energy efficiency measures generally involve change. There are changes either to equipment or to operating and maintenance practices, and there are continuing changes in the available technologies. At any facility, ensuring that the best practices and equipment are being applied requires ongoing, dedicated effort. This is critical not only for ensuring that the technologies work as planned and for refining them when needed, but also for separating successful approaches from poor ones.

EFFICIENT TECHNOLOGIES FOR MAJOR ENERGY USES

This section examines some of the main energy uses found in Federal commercial and residential buildings, and some technologies applicable to energy efficiency gains.[35]

Lighting

Lighting is ubiquitous in commercial buildings, and is responsible for around 25 to 50 percent of electricity use in those buildings. In addition to the energy used directly by the lights, heat produced by lights contributes significantly to air conditioning loads in commercial buildings, indirectly contributing to additional electricity demand. Lighting is a far smaller contributor to residential energy use, but still affords some economic opportunities.

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[34] For an in-depth discussion of energy audits, see Albert Thumann, *Handbook of Energy Audits* (Lilburn, GA: Fairmont Press, Inc., 1983).

[35] For an exhaustive description of a wide range of energy efficient measures, see for example, *Architect's and Engineer's Guide to Energy Conservation in Existing Building: Volume 2—Energy Conservation Opportunities*, prepared for U.S. Department of Energy, DOE/RL/01830P-H4, April 1990. That report describes 118 energy conservation opportunities using currently available products which could be considered for commercial buildings. Also see Battelle-Columbus Division and Enviro-Management & Research, Inc., *DSM Technology Alternatives*, EPRI EM-5457 (Palo Alto, CA: Electric Power Research Institute, October 1987), for descriptions of 99 energy efficiency technologies which can affect electricity use.

Many lighting measures for commercial building applications have been heavily researched over the past two decades.[36] During this time, a wide range of approaches and products for improving the performance of lighting have been pursued and implemented. Several lighting measures now available appear to offer considerable energy- and cost-saving potential, with attractive reliability and performance. (Table 3-2 summarizes the main approaches to the more efficient use of electricity for lighting.) The three main approaches are: reduce unneeded illumination, increase efficiency of lamps, and increase efficiency of fixtures.

General Services Administration together with the Department of Energy (DOE) have announced a $10-million program to make use of energy efficient lighting measures in the National Capital Region. This program will take advantage of an energy efficiency incentive program offered by the Potomac Electric Power Co., the local electric utility.

The Defense Logistics Agency (DLA) takes the lead for Federal procurement of lamps and ballasts and resale to other agencies. In 1989, this responsibility was transferred from GSA, which retains main responsibility for other lighting products such as fixtures. DLA does not emphasize high efficiency products in its role as main provider of bulbs and ballasts.

Reduce Unneeded Illumination

Delamp overlit areas, use task lighting. Any effort to reduce illumination levels needs to be based on a careful, site-specific analysis of illumination requirements. Failure to do so can cause worker dissatisfaction and perhaps reduced performance, neither of which are consistent with energy efficiency efforts.

However, buildings often have higher illumination levels than needed for occupant comfort. Minimum illumination levels are specified by facility engineers, the Illumination Engineering Society, and others depending on the type of activity. For example, GSA requires 50 foot-candles of illumination for desks, and 30 foot-candles for hallways. Lighting levels can be reduced very inexpensively by removing lamps, as in the case of removing two lamps and disconnecting one of the ballasts in a four-lamp fixture. Using lower output lamps may also reduce power, as in using 34-watt fluorescent tubes to replace standard 40-watt tubes. In this case, the 34-watt tubes are slightly more efficient than the 40-watt tubes, and light levels are not proportionately reduced. Task lighting allows reducing overall light levels by increasing light on the desk or working surface.

Table 3-2—Lighting Efficiency Measures

Reduce unneeded illumination
- Delamp overlit areas
- Use task lighting
- Use lighting controls
  - Occupancy sensors and timers
  - Daylight with automatic dimmers

Increase efficiency of lamps and ballasts
- Use high-efficiency lamps
- Use high-efficiency ballasts

Increase efficiency of light fixtures
- Use reflectors and high-efficiency fixtures
- Clean and maintain fixtures

SOURCE: Office of Technology Assessment, 1991.

Use lighting controls such as occupancy sensors, timers, and daylighting with automatic dimmers. A variety of methods for turning lights off when not needed have been developed and demonstrated in practice.[37] Turning lights off which are not needed can both reduce energy use and extend replacement time for the lamps. Frequent switching reduces fluorescent lamp operating lives, but with modern tubes only a short period of being turned off compensates for the additional switching. Automatic switching using occupancy sensors is more reliable and convenient than manual switching, and is well suited to bathrooms, conference rooms, and some hallways and private offices. Simple timed switches are inexpensive, and perform well in locations such as storerooms. Several brands of occupancy sensors have established good operating records, and when installed in a suitable location have good economic characteristics. Detailed site surveys and analyses are not required for occupancy sensors and timers. However, a reasonable estimate of the schedule of use of lights and the opportunity for curtailing use is needed.

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[36] See Albert Thumann, *Lighting Efficiency Applications* (Lilburn, GA: Fairmont Press Inc., 1989).

[37] See, for example F. Rubinstein and R. Verderber, "Automatic Lighting Controls Demonstration," prepared for Pacific Gas & Electric Co., March 1990. This project, which combined a variety of control strategies centering around dimming electronic ballasts, demonstrated savings of over 50 percent with a payback of under 2 years for a small office space.

Automatic dimming controls sense lighting levels and turn down lights when daylight is present. They may be suitable for use in offices at building perimeters or near skylights. Daylighting is finding increased use in new buildings and retrofits, but is not widely applied. Opportunities are highly site-specific.

Increase Efficiency of Lamps and Ballasts

Tremendous advances have been realized in the efficiency of bulbs and ballasts over the past decade, many of which are not widely used in Federal facilities. Most of the commonly used types of lamps, including fluorescent, incandescent, mercury vapor, metal halide, and high- and low-pressure sodium, have all had significant performance improvements. Demand for some new high-efficiency compact fluorescent lamps and electronic ballasts has grown so rapidly that it may outstrip supply.[38]

Fluorescent Lamps and Ballasts—Many high efficiency lamps and electronic or hybrid electronic/magnetic ballasts that replace standard fluorescent tubes and standard magnetic ballasts have been commercialized. Laboratory studies indicate that the most efficient combination presents savings opportunities of up to 39 percent compared with standard tubes and ballasts.[39] Table 3-3 compares the efficiency of different combinations of ballasts and lamp efficiencies for "cool white" 4-foot tubes. At least some of the products available have been well-proven in widespread use and noted in industry press.[40] In 1988, electronic ballasts captured around 4 percent of the market, a small amount but enough to prove reliability.[41]

Table 3-3 also shows the bulk costs of ballasts and tubes. Generally, the higher the efficiency of lamps and ballasts, the higher the first cost. However, the cost of lamps and ballasts is less than the cost of the electricity those components will use in their lifetime. Paybacks for replacement and for use in new construction are often rapid, under 3 years. For example, the T-8 tubes and electronic ballasts appear to have clearly superior economic characteristics compared with standard fluorescents for use in new construction and when existing components reach the end of their life. Performance is comparable or superior to that of standard systems, with better color and reduced flicker, although some ballasts may generate power quality problems such as unwanted harmonics. In many cases, early replacement (e.g., replacing a still-functioning lamp) with high efficiency components is economically attractive.

Prior to 1990, standard magnetic ballasts, hybrid electronic/magnetic ballasts, and electronic ballasts were all available in the commercial market from several manufacturers. However, the National Appliance Efficiency Act of 1988 set a minimum efficiency standard for most common ballasts which removes standard ballasts from the domestic market. Even though the least efficient ballasts are no longer manufactured, existing stocks are still marketed. This, together with their long 10-year lifetime, means that these costly-to-operate devices will continue to consume excessive amounts of electricity and Federal energy dollars for several years.

Incandescent Lamps—While the majority of lighting fixtures in most commercial buildings are fluorescent, some incandescent lamps are also used. In contrast, most residential lighting is incandescent. Over the last few years, fluorescent lighting technology has gradually improved, with the lights gradually becoming small and light enough to substitute for screw-in incandescent lamps in certain fixtures. These compact fluorescent lamps consume only about 25 percent of the power of a standard incandescent lamp of the same light output. However, compact fluorescent lamps remain considerably heavier and larger than incandescent lamps, and thus cannot always be used in the existing fixtures.

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[38] "As DSM Programs Gain, Consultant Warns of Possible Lamp Shortages," *Electric Utility Week*, Feb. 25, 1991, p. 14.

[39] "Performance of Electronic Ballasts and Lighting Controllers With 34-W Fluorescent Lamps: Final Report," Lawrence Berkeley Laboratory, February 1988.

[40] See for example, R.S. Abesamis, P. Black, and J. Kessel, "Field Experience With High-Frequency Ballasts," *IEEE Transactions on Industry Applications*, vol. 26, No. 5, p. 810-811, which describes the successful application of over 45,000 high-frequency electronic ballasts at the University of California at Berkeley.

[41] U.S. Department of Energy, "Trends in Energy-Efficient Lighting," Conservation and Renewable Energy Inquiry and Referral Service (CAREIRS), March 1990.

Table 3-3—Comparison of Fluorescent Lamps
(77 test room — 4-lamp recessed troffer, plastic lens)

Lamp type	Ballast	Ballast factor[1] [a]	Watts[a]	Relative light output[2] [a]	Relative light output/watt[a]	Cost[5] [b] [c]
T-12 standard (40 W)	Standard magnetic[4]	0.95	174	100	100	n/a
T-12 energy-saving (34 W) rare earth tri-phosphor	Standard magnetic[4]	0.90	155	93	104	n/a
T-12 standard (40 W)	Energy-saving magnetic	0.95	162	101	108	26.80
T-12 energy-saving (34 W) rare earth tri-phosphor	Energy-saving magnetic	0.88	139	91	114	27.80
T-8 lamp (32 W)[3]	T-8 electronic	0.92	106	98	161	47.80

NOTES: 1. Data in test normalized to ballast factors shown in this column for magnetic ballasts. Factors shown for electronic ballasts are measured values of sample.
2. Relative light output based on initial (100 hour) rated lamp lumen output.
3. Life rated at 15,000 hours. All other systems shown are rated at 20,000 hours.
4. Standard magnetic ballasts are only available for export since the National Energy Appliance Conservation Act (NEACA) passed in 1989.
5. Cost column is the cost of the lamp multiplied by four, plus the cost of the ballast.

SOURCES: [a] National Electrical Contractors Association.
[b] Jim Osborne, Magnetek, personal communication, February 1991.
[c] Customer Service, General Electric Lighting, personal communication, Mar. 11, 1991.

A compact fluorescent lamp is far more expensive than the incandescent it replaces. For example, a 15-watt compact fluorescent purchased by the Federal Government costs around $7, compared to about $0.30 for the 60-watt incandescent it replaces.[42] However, savings on both energy costs and maintenance costs can be very high if the lamp operates a few hours a day or more. For example, for lights turned on 8 or more hours per day on weekdays, compact fluorescent lamps can pay for themselves in under 1 year.[43] Maintenance savings result because the fluorescent lamps have a lifetime 10 times longer than standard incandescents, potentially decreasing maintenance and replacement costs considerably. However, for an incandescent turned on only 1 hour per day, the potential savings are small relative to the cost of a compact fluorescent.

Use of compact fluorescent replacements for incandescent lamps is increasing in the commercial sector. However, further advances (notably in size and weight) are necessary before they become the rule rather than the exception for even heavily used lights. For occasionally used lights, considerable reduction in first cost is also necessary.

For incandescent fixtures in which compact fluorescent lamps are too heavy or too large to work, higher efficiency incandescents are available which reduce consumption by 10 to 20 percent and produce the same light output.

Use High Efficiency Fixtures

In the past several years, a large number of new fixtures have been marketed, intended to improve the distribution of light, increase efficiency, and improve visual comfort. The key features of high efficiency fixtures are reflectors and lenses which direct light toward the working space. High reflectance silver or aluminum reflectors inserted into fluorescent fixtures can increase fixture efficiency by 20 to 35 percent.[44] Also, because the efficiency of fluorescent tubes decreases outside a certain range of operating temperatures, a feature of efficient fixture design allows heat dissipation to maintain optimal bulb temperatures.[45] Measuring the performance of fixtures is difficult, depending not only on the level of illumination resulting, but the distribution of light at the working surface.

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[42] General Electric Customer's Service, personal communication, Mar. 26, 1991.

[43] Annual savings in cost-of-energy is about:
(8 hour/day) * (235 days/year) * (0.045 kilowatts) * ($0.07/kilowatt-hour) = $6/year.
Incandescent lamps, with an average lifetime of 1,000 hours, must be replaced twice per year if operated 8 hours daily, so the compact fluorescent additionally saves about 1/2 hour of labor, approximately $10 for typical maintenance workers. Note that benefits from reduced maintenance may not accrue if maintenance workers are made idle but remain on the payroll.

[44] T.K. McGowan and H.H. Whitmore, "Performance of Fluorescent Reflector Inserts," GE Lighting, Nela Park, OH, undated.

[45] See *Energy Conservation Potential Associated With Thermally Efficient Fluorescent Fixtures*, Lawrence Berkeley Laboratory, CA, prepared for Department of Energy, Washington, DC, June 89.

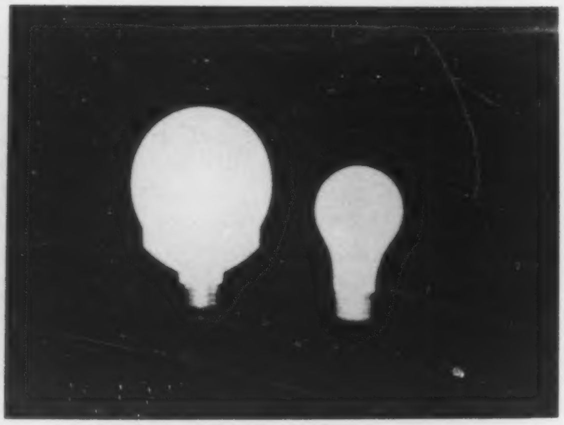

Photo credit: Christine Onrubia

Compact fluorescent lamps are nearly four times more efficient than incandescent lamps, but are too large to fit in many popular fixtures.

To keep any fixtures operating optimally, basic maintenance in the form of cleaning is required. The light from very dirty fluorescent fixtures and lamps may be less than 70 percent the light from the same equipment when clean.[46] It is possible that high efficiency fixtures may be more susceptible to dirt-induced degradation than standard counterparts.

Future Directions in Lighting Efficiency

Advances in lighting technology are continuing along a variety of fronts. Better lamps, ballasts, and fixtures are all being pursued by manufacturers. These efforts should continue to improve the prospects for efficiency, applicability, and customer acceptance. One area which could benefit from additional effort is product testing. Performance, including efficiency, visual comfort, and reliability of new products is often difficult to gauge. Because lighting technologies are constantly evolving, systematic testing and reporting from a reliable source could be of considerable help to building managers, with their limited time and resources to explore the vast array of available options.

Heating, Ventilation, and Air Conditioning

As with lighting, HVAC is ubiquitous in commercial and residential buildings, including those owned and assisted by the Federal Government. In many buildings, heating, ventilating, and air conditioning, in total, account for the majority of both electric energy use and energy use overall.

During the past two decades, many approaches have been heavily researched which can reduce the energy needed for heating, ventilating, and air conditioning.[47] (Table 3-4 summarizes the main approaches to the more efficient use of energy for HVAC.) The two main approaches are: improve the building envelope and increase efficiency of HVAC equipment including efficient operation and maintenance.

Improve Building Envelope

HVAC use depends in part on the amount of heat gained (during summer) or lost (during winter) through a building's envelope (the exterior walls, windows, doors, roof, and floors). Envelope improvements control heat gain or loss to reduce the load on HVAC systems. With many HVAC-related measures, retrofitting existing buildings is more difficult and expensive than installing them during construction, highlighting the importance of good initial design for new Federal buildings.

Infiltration, the unintended and uncontrolled entry of outside air into a building, may add considerably to a building's heating and air conditioning load. Some measures to control infiltration such as caulking and weatherstripping doors and windows, and ensuring windows are kept closed when HVAC is being used, are low cost and part of a good, ongoing facility maintenance program. These measures should be pursued at all Federal facilities. Other measures such as adding vestibules or revolving doors or vapor barriers in walls require capital spending but may be worthwhile in some buildings.

Conduction, the transfer of heat through walls, roofs, windows, floors, and doors, also contributes to heating and air conditioning demand. Opportunities for adding insulation in any Federal facility depend greatly on the type of building, including its age, location, condition, type of construction, and existing insulation. There are a variety of insulation products available for walls, floors, and ceilings, some of which have been manufactured using chlorofluorocarbons (CFCs). These products will be

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[46] Illuminating Engineering Society, *Lighting Handbook* (New York, NY: 1972).

[47] For an in-depth discussion of many well-established measures, see D. Paul Mehta and A. Thumann, *Handbook of Energy Engineering* (Lilburn, GA: Fairmont Press, Inc., 1989).

Table 3-4—HVAC[a]-Related Efficiency Measures

- ***Improve the building envelope***
  - Reduce infiltration
    - Caulk and weatherstripping
    - Vestibules and revolving doors
  - Insulate
    - Roofs walls, floors
    - Storm doors and windows
    - Vapor barriers in roofs and walls
  - Reduce solar heat gain through windows and roofs
    - Shading
    - Reflective window films
    - Reflective roof surfaces
- ***Increase efficiency of HVAC systems***
  - Perform system maintenance regularly
  - Operate equipment efficiently
    - Install and use an energy management system
  - Install efficient equipment
    - Ventilation equipment
    - Chillers, air conditioners, and cooling systems
    - Boilers and furnaces
    - Distribution systems

[a] Heating, ventilation, and air conditioning.

SOURCE: Office of Technology Assessment, 1991.

effected by restrictions on production and use of CFCs due to the atmospheric environmental impacts. Both relatively new and long-existing products are also available to decrease conduction through doors and windows. Storm doors and windows, a long-proven technology, reduce heat gain or loss. New "low emissivity" or "insulating glass" windows, used with or without storm windows, can greatly further reduce heat transfer.

Solar heat gain through windows and roofs can add considerably to cooling loads and decrease winter heating loads. Both window and roof solar heat gain can be controlled using simple and inexpensive measures in many cases. For example, the amount of solar heat gained through a roof can be reduced by using reflective or light-color paints on the roof. Solar heat gained through windows can be reduced using reflective films or shading, either with roof or wall overhangs or with trees for some low buildings. The benefits of measures to control heat gain depend on many factors including building size, orientation toward the sun, side of the building effected, and climate. Selecting measures requires a careful analysis of these factors as well as the tradeoff between the benefits in summer and the potential losses in winter.

Increase Efficiency of HVAC Systems

Space heating in Federal facilities is provided with a variety of equipment. Most facilities use natural gas or oil in a boiler which makes steam or hot water, or a furnace which makes warm air. The steam, hot water, or warm air is distributed through a building using a system of pipes or ducts. Many buildings also use electricity for heating, using heat pumps or electric resistance heaters, which often need no distribution system.[48] There is a similar variety of cooling equipment including central chillers which produce either chilled water or air, and local heat pumps or air conditioning units. Often, the same system of pipes or ducts is used for both heating and cooling, depending on the season.

Preventive Maintenance—Besides turning equipment off when not needed, the simplest and most basic energy efficiency measure for HVAC systems is a program of regular preventive maintenance. All HVAC system equipment including distribution equipment, requires regular maintenance for peak performance and efficiency, but will continue to function (inefficiently) even if not properly maintained. For that reason, regular preventive maintenance, rather than maintenance when equipment fails is essential.

The list of maintenance items can be long and depends on the specific equipment.[49] Some maintenance steps such as cleaning burner tips in boilers using heavy fuel oil and checking controls may be required as frequently as daily and may almost be considered part of efficient operations. Others need to be performed weekly or monthly or annually. Examples include such functions as cleaning or replacing air filters in ducts and air conditioners, cleaning boiler surfaces, cleaning evaporators and condensers in chillers, and repairing leaks in ducts, pipes, and boilers. Simple maintenance steps, if not already being performed, could lead to considerable cost savings.

Anecdotal evidence indicates that at least some potential gains exist. For example, one study of the HVAC system at DOE's Forrestal building in

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[48] U.S. Department of Energy, Energy Information Administration, *Nonresidential Buildings Energy Consumption Survey: Commercial Buildings Consumption and Expenditures 1986*, DOE/EIA 0246(86) (Washington, DC: U.S. Government Printing Office, May 1989), p. 168.

[49] For a discussion of maintenance practices, see Paul D. Mehta and A. Thumann, *Handbook of Energy Engineering* (Lilburn, GA: Fairmont Press, Inc., 1989), ch. 14, "Energy Management."

Washington, DC found that an intensive program of steam trap maintenance and repairs together with simple operational changes such as turning the steam system off on weekends reduced total building energy costs by over 6 percent, or $260,000.[50] Similarly, one review of twelve variable-air-volume air conditioning systems at six Navy facilities found that "the general level of operating and maintenance services being supplied is very poor and not sufficient to make . . . systems function properly. There appears to be no effective preventive maintenance/inspection program."[51] Finally, at OTA's site visits to four federally owned facilities, personnel in at least two sites expressed some doubt that HVAC maintenance or operations were carefully conducted for efficiency. There seem to be no systematic mechanisms or incentives to ensure that HVAC systems in Federal facilities are properly maintained for peak efficiency. This is not to say that Federal agencies ignore operations and maintenance issues. GSA, for example, requires building managers to keep plans for efficient operation, and has standards for maintenance intended to ensure efficiency. Examining the different approaches taken by Federal agencies and private-sector facility managers to see which work best, and applying those methods throughout Federal facilities could be very productive.

Efficient Operation—Closely related to efficient maintenance, efficient operation is another low cost measure to minimize energy use and cost. Efficient operation involves carefully monitoring ambient temperature and humidity as well as heating and cooling demand, and operating equipment accordingly. As with maintenance, there are a variety of measures to pursue which together help ensure efficient operation. For example, in systems with multiple chillers, efficiency can be improved by isolating one or more units during periods of light cooling demands (e.g., early mornings). Another simple method is to adjust boiler or chiller output to the minimum required level, which depends on heating and cooling demand. Also, use of economizer cycles, which use outside air for cooling when temperature and humidity are suitable, can produce substantial savings. The opportunities for energy- and cost-savings from efficient operations depend on the type of equipment, the characteristics of the facilities, and the efficiency of current operations.

Energy Management and Control Systems—Sometimes, adding new equipment can help improve the efficient operations of existing equipment. One type of such equipment, developed largely to ensure efficient operations of existing HVAC systems, is the building energy management and control system (EMCS). There are several commercial vendors of EMCS.

The functions performed by an EMCS can be as simple as shutting off the HVAC system after normal business hours. However, there are also increasingly sophisticated, computer-based systems with perhaps thousands of temperature and humidity monitoring points throughout a facility, as well as monitors of ambient conditions and HVAC equipment performance. This information, coupled with detailed, automated control of the HVAC equipment's fuel, air, temperature, and other equipment settings, can be used to minimize energy and operating cost. Also, the remote and continuous monitoring of the performance of HVAC system components allows operators to identify areas needing maintenance. For example, an EMCS can continuously monitor the input and output water temperatures and fuel use in a boiler, which together indicate the boiler's efficiency. Reduced efficiency indicates that maintenance is needed, possibly as simple as cleaning boiler surfaces or burners tips.

Properly installed, maintained, and used, an EMCS can greatly aid in reducing operating and maintenance costs. It also can help measure and document energy savings. However, it is not a magic tool. To reach its full potential, an EMCS requires not only a combination of good equipment, and proper design and installation by the vendor, but also an ongoing period of training, followup work, and maintenance by the HVAC operators. HVAC operators need to have time to dedicate to learning the system capabilities, and experiment with different approaches to using both the HVAC and EMCS equipment. For example, operators can experiment with different boiler temperature settings which depend on ambient temperatures and humidity, as well as temperatures and humidity at different points within the buildings being heated. Because every facility is unique, the opportunities for EMCS to improve HVAC operation must be individually tailored. This requires a capable, well-trained, and interested operations staff.

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[50] Jeff S. Haberl and E. James Vajda, "Use of Metered Data Analysis To Improve Building Operation and Maintenance: Early Results From Two Federal Complexes," paper presented at American Council for an Energy-Efficient Economy, 1988 Summer Study on Energy Efficiency in Buildings, Asilomar, CA, Aug. 28 to Sept. 3, 1988.

[51] Tom R. Todd, "Maintenance of Variable-Air Volume HVAC Systems," in Federal Construction Council, *Technical Report No. 95: Maintenance of Mechanical Systems in Buildings* (Washington, DC: National Academy Press, 1990), pp. 19-23.

Many EMCS' have been installed in Federal facilities, and individual agencies have supported ongoing efforts to improve their performance. However, results to date are mixed.[52] All of the four federally owned commercial facilities in OTA's site visits had some sort of EMCS equipment, some of it fairly old. However, in at least two cases the EMCS equipment was not being used as intended in its design, apparently due to some combination of improper design, installation, maintenance, and training. According to one study, ". . . Federal agencies have had significantly more HVAC control problems than private owners."[53] That study suggested that adopting some private sector approaches could improve performance in Federal facilities. Those include giving consulting engineers more flexibility in designing systems; requiring consulting engineers to write more detailed specifications (e.g., the accuracy and location of thermometers and the precise conditions which should cause valves to be opened or closed); and involving the consulting engineers in the installation and startup of new systems to ensure they are properly operational and that agency personnel are properly instructed.

Install Efficient Equipment

Much HVAC equipment in use today in Federal facilities is quite old. Large improvements have occurred in the efficiencies of chillers, air conditioners, boilers, furnaces, and the motors which power pumps and fans in HVAC equipment.[54] For example, a new packaged air conditioning unit may consume 30 percent less energy than one manufactured in the 1960s. High efficiency heat pumps have attractive cost and performance characteristics in warmer climates, providing both air conditioning in summer and space heating in winter. As old equipment is replaced over time, efficiency will generally increase. However, there is a fairly wide range of efficiency in equipment being produced today. Typically, higher efficiency equipment is more expensive than less efficient counterparts, but generates cost savings over its long life. Trading off between higher first cost and lower operating costs requires careful engineering and economic analysis.

Some components can be kept working for decades. Because equipment costs are high, replacing working equipment is often not cost effective. Still, some of the HVAC equipment in Federal facilities may be past its economic life. Unfortunately, analysis of whether replacing an existing unit would reduce net costs is usually not made: equipment is used until it ceases to work.

Miscellaneous Energy Uses

Miscellaneous energy uses include everything not mentioned above. They are a small but rapidly growing portion of building energy use, with developments such as office automation and computing, advanced medical scanning technologies, and simulators gaining use. Some of the other many miscellaneous uses are more traditional, such as water heating, cooking, refrigeration, and elevators.

There are many opportunities for efficiency improvements in miscellaneous energy uses (see box 3-A). For example, water heating for commercial use can be made more efficient with well-proven approaches including using new heaters with pulsed combustion and better insulated tanks, and insulating distribution piping. Another example of an opportunity for increasing miscellaneous use efficiency is in new electric motors. Motors are used in a variety of commercial applications, from elevators to HVAC pumps and fans to postal automation equipment. The most efficient electric motors available in today's markets are considerably more

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[52] For an example of a system which has to date failed to meet expectations, see F. Boercker and J. McEvers, "A Post-Installation Review of the Energy Monitoring and Control System at Red River Army Depot," Oak Ridge National Laboratory, ORNL/TM-10137, May 1990. Other installations have had successful EMCS applications. See, for example, Douglas A. Decker, "A Self Financing Energy Conservation Concept for the Federal Government," *Strategic Planning for Energy and the Environment*, vol. 10, No. 3, winter 1990-91, pp. 64-66, which describes cost savings at the U.S. Army's Fort Eustis, VA using EMCS.

[53] See Building Research Board, National Research Council, *Controls for Heating, Ventilating, and Air-Conditioning Systems* (Washington, DC: National Academy Press, 1988), pp. 23-24, 43,44.

[54] For a description of high-efficiency electrical HVAC equipment, see Resource Dynamics Corp., *Handbook of High-Efficiency Electric Equipment and Cogeneration System Options for Commercial Buildings*, EPRI CU-6661, December 1989; and D.W. Abrams, P.E. & Associates, *Commercial Heat Pump Water Heaters Applications Handbook*, EPRI CU-6666 (Palo Alto, CA: Electric Power Research Institute, January 1990).

Box 3-A—A New, Improved Exit Sign: What Difference Could It Make?

There are hundreds of thousands of exit signs in Federal commercial buildings, consuming in total several megawatts of power around the clock.

Exit signs are one excellent example of energy- and cost-saving technological progress, even though they represent only a tiny fraction of total electricity use in buildings. For decades, exit signs in commercial buildings have commonly been lit by a pair of standard incandescent lamps. Though at $0.20 each they are cheap to buy, these lamps are expensive to use since they operate inefficiently around the clock. Each sign consumes from 210 to 1,050 kWh/year at a cost of $15 to $75; the need to replace these lamps as they burn out as often as every 2 months adds around $60 annually to their total cost.[1]

By replacing the incandescent lamps in existing signs with compact fluorescent lamps, energy costs are considerably decreased to between $7 and $11. Even more significantly, the 10,000-hour life of a compact fluorescent means the $6 lamp needs replacement less than once per year, giving an average annual maintenance cost of only $14. The total annual savings compared to an incandescent exit sign are between $55 and $110. Lower operating and maintenance costs in the first few months alone more than pay back the higher initial lamp and ballast cost of $15 and installation.

While the compact fluorescent is a clear advance over incandescent-based exit signs, a further improved exit sign technology has recently been commercialized. Exit signs relying on light-emitting diodes (LED) are even more energy efficient and less expensive to operate, using as little as 6.7 watts. Furthermore, these signs need infrequent replacement or maintenance (the electrical components have a life expectancy of 25 to 30 years). LED signs are available under a General Services Administration authorized Federal Supply Schedule[2] for as low as $71.47, only slightly more expensive than a new exit sign using incandescent lamps and actually less expensive than a new sign with a compact fluorescent.[3] Thus, when purchasing new exit signs (e.g., for new construction), LEDs should produce net cost savings right from the start or soon thereafter. Even when used to replace an existing fluorescent-lamp exit sign, they should produce a simple payback of under 4 years.

Photo credit: Gilbert Emergency Lighting

If used in all Federal facilities, exit signs using light-emitting diodes could be a cost-effective way to save several megawatts of electric generating capacity.

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[1] This example uses the following assumptions: electricity costs $0.07/kWh; each standard fixture uses a pair of incandescent lamps totaling from 24 to 120 watts, or a single 12- to 18-watt compact fluorescent; average incandescent lamp life is 2,000 hours; lamp replacement requires $10 in labor costs which can be put to other productive use or displaced. Note that if a facility has surplus maintenance workers, labor cost savings will not actually accrue. These assumptions are adapted from "Exit Signs: Save Energy and Money," *Energy & Environmental News*, Naval Energy and Environmental Support Activity, Port Hueneme, CA (reprinted in U.S. DOE, *FEMP Update*, Federal Energy Management Program, winter 1983, p. 11).

[2] GSA contract #GS07F-1862A with Don Gilbert Industries, Inc., Mar. 26, 1990 to Aug. 31, 1994.

[3] Standard electrical exit signs using incandescent lamps cost as little as $61.50. GSA Contract Catalog GS07F-18188, Mar. 1, 1990 to Aug. 31, 1994, EMED Co., Inc., p. 11. While the lamps are described in the catalog as "extra long life energy saving lamps," according to the manufacturer they are incandescent rather than fluorescent. Telephone conversation with customer services department, Nov. 26, 1990.

efficient than older motors (also far more efficient than the least efficient models currently available). Also, developments in adjustable speed drives can create higher efficiencies by allowing a motor's electric power input to vary with the load and may be suitable in some applications.

Refrigerators

Refrigerators offer an opportunity for a large reduction in electricity use in the 9 million federally owned or assisted households. Each year around half a million new refrigerators are purchased for these households. The average refrigerator now operating in the United States uses over 1,500 kWh/year.[55] The most efficient commercially available models of similar size use less than 60 percent of that amount.[56] The stock of refrigerators in federally owned and assisted households may include smaller units with fewer energy-using features, such as through-the-door ice and water dispensing, than the national average, slightly reducing the average potential gains there.

Some of the potential is gradually being captured. The National Appliance Energy Conservation Act of 1988 (NAECA) set minimum standards for several appliances, including refrigerators. However, even with NAECA, the long lives of refrigerators (over 15 years) ensures that inefficient units will continue to be used in Federal facilities for many years unless retired early. Further, even as refrigerators are replaced in federally owned and assisted households, there is no guarantee that the most energy efficient units will be selected rather than those minimally meeting the standards. As in the purchase of any energy-consuming device, several factors such as durability and features must be considered as well as first cost and energy use when selecting a refrigerator. In addition to opportunities in buying more efficient refrigerators, regular maintenance (i.e., cleaning condenser coils) can improve efficiency.

New Miscellaneous Uses

Most new miscellaneous energy uses rely on electricity. All are used because of the significant improvements in performance or productivity they bring. These new miscellaneous uses contribute to increasing energy use at Federal facilities (or smaller energy savings). However, these increasing uses of energy are not only legitimate, but may be essential to increasing overall Federal productivity and services. For example, use of automated mail sorting equipment can increase energy consumption in mail facilities (see case study of the U.S. Postal Service San Diego Division in ch. 5). At the same time, it helps speed deliveries and reduce labor requirements.

Some new miscellaneous energy uses, while increasing electricity use in the Federal buildings can actually contribute to reduced overall energy use. For example, military use of simulators has increased tremendously over the past decade. Military training on simulators is used for a wide range of equipment, including various aircraft, tanks, and even small arms. A flight simulator can use a considerable amount of electricity. However, the amount of jet fuel used in an actual training flight is far more than enough to compensate for the electricity.

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[55] U.S. Department of Energy, Energy Information Administration, *Housing Characteristics 1987*, DOE/EIA-0314(87) (Washington, DC: U.S. Government Printing Office, May 1989), p. 10.

[56] *1990 Directory of Certified Refrigerators and Freezers* (Chicago, IL: Association of Home Appliance Manufacturers, January 1990).

Chapter 4

Federal Energy Use in General Operations

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Chapter 4

Federal Energy Use in General Operations

FEDERAL GENERAL OPERATIONS ENERGY USES

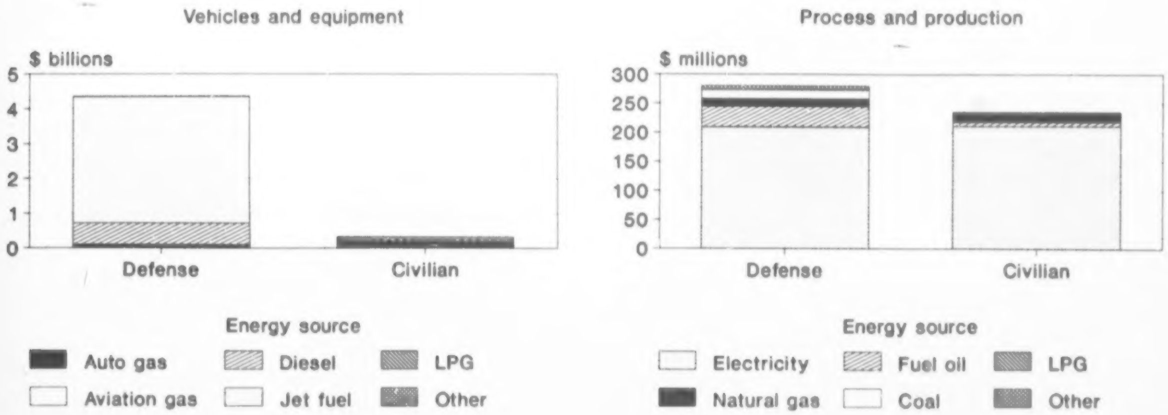
General operations energy uses in the Federal Government can be grouped into three categories: passenger vehicles and trucks; other vehicles and transport equipment (e.g., military aircraft and Naval fleets); and energy-intensive processes and equipment such as uranium enrichment facilities.

The great majority of the $4.8 billion spent on general operations energy in fiscal year 1989 was used for military mobility, including $3.6 billion for jet fuel (see figure 4-1). Much of the remaining operations energy use is also defense-related, used by the Department of Defense (DOD) in various processes and by the Department of Energy (DOE) in its uranium enrichment facilities and production nuclear reactors. Production reactors are industrial facilities for producing nuclear weapons material and nuclear fuel. Nondefense operations using large amounts of energy include DOE's research facilities such as reactors and linear accelerators.

General operations accounts for 92 percent of Federal petroleum use.[1] Again, the great majority of this petroleum is for jet fuel, and much of the remainder is used in military vehicles (see figure 4-2).

Because of the highly specialized nature of most operations energy uses (e.g., military mobility), examination of opportunities for energy and cost savings are largely beyond the scope of this report, with the exception of the fuel used in passenger vehicles and trucks. Specialized operations have also received far less detailed attention in Federal energy management legislation and Executive orders than energy use in buildings and vehicle fleets. However, there are energy saving opportunities, at least some of which are being tapped. For example, DOE completed a number of process retrofits including the installation of variable air volume control on fume hoods and makeup air systems at the Lawrence Livermore National Laboratory. DOE is planning more efficiency measures involving use of waste heat, advanced control systems, and scheduling of equipment.[2] There are also measures which,

Figure 4-1—General Operations Costs, Fiscal Year 1989



SOURCE: U.S. Department of Energy, Federal Energy Management Program, "Annual Report to Congress on Federal Government Energy Management and Conservation Programs," October 1990.

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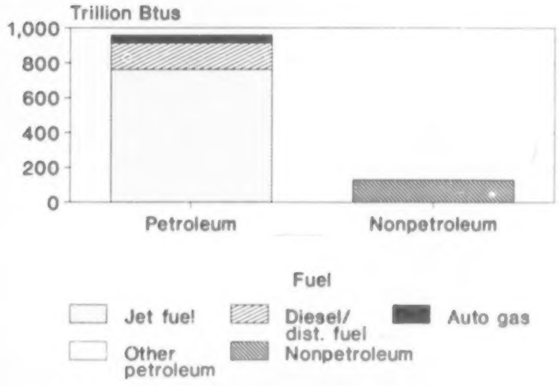
[1] U.S. Department of Energy, Federal Energy Management Program, "Annual Report to Congress on Federal Government Energy Management and Conservation Programs," October 1990, p. 5.

[2] Ibid., p. 49.

Figure 4-2—Operations Energy Use by Fuel, Fiscal Year 1989



NOTE: Source accounting used for electricity.

SOURCE: U.S. Department of Energy, Federal Energy Management Program, "Annual Report to Congress on Federal Government Energy Management and Conservation Programs," October 1990.

although not performed primarily to save energy, do reduce energy use even for military mobility. For example, many flight simulators are in use by DOD. They supplement actual flying time and allow for improved pilot training with greater safety and lower cost. Part of the cost savings results from greatly reduced fuel consumption (e.g., fighter aircraft can consume more than 1,000 gallons per hour). Similarly, there are simulators for surface vehicles such as tanks. Although the use of simulators increases the use of electricity, this is more than offset by the reduction in fuel consumption.

PASSENGER VEHICLES AND TRUCKS

In total the Federal Government owned 106,108 sedans, 15,973 station wagons, and 323,479 light trucks in 1988. In addition, there were 12,641 buses and ambulances and 55,481 medium and heavy trucks. DOD and the U.S. Postal Service (USPS) have the largest fleets, each with about 30 percent of the total. The General Services Administration (GSA), which has oversight responsibility over federally owned and leased passenger vehicles, has about 20 percent of the total which it leases to other agencies.[3] Almost all Federal agencies own at least one vehicle and may lease many others from the GSA Federal Fleet Management System (figure 4-3).

The number of federally owned passenger vehicles and trucks is a very small percentage of the total in the United States, about one-quarter of 1 percent. As of 1988 there were 140 million automobiles and 43 million trucks and buses registered in the United States.[4] Despite the small number of federally owned vehicles, Federal procurement is responsible for nearly 1 percent of domestically produced vehicles. There are two reasons. First, agencies keep their automobiles and light trucks for only 3 to 6 years before replacement.[5] Thus each year, the government purchases around 100,000 cars and light trucks. (About 50,000 of these are procured by GSA.) Second, the Federal Government historically has purchased only domestic models for use in the United States.

In fiscal year 1989, the Federal fleet, including medium and heavy trucks, consumed over 329 million gallons of gasoline at a cost of $309 million.[6] In 1988, the domestic fleet covered more than 3.5 billion miles, and the average Federal sedan traveled 13,027 miles.[7]

Increasingly the Federal auto fleet is relying on compacts. In 1988 compacts outnumbered other classes of sedans by almost two to one. The shift in the makeup of the Federal fleet to smaller, more fuel efficient cars has resulted in higher fleet average fuel mileage. With few exceptions, the Federal automotive fleet uses conventional petroleum fuels (i.e., gasoline and diesel fuel), although there are some alternate fuel vehicles.

Three promising ways to reduce the Federal Government's passenger vehicle energy use are: 1) purchase automobiles with higher fuel economy, 2) encourage drivers to drive more efficiently, and

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[3] U.S. General Services Administration, Office of Fleet Management, "Federal Motor Vehicle Fleet Report for Fiscal Year 1988," September 1990, table 7.

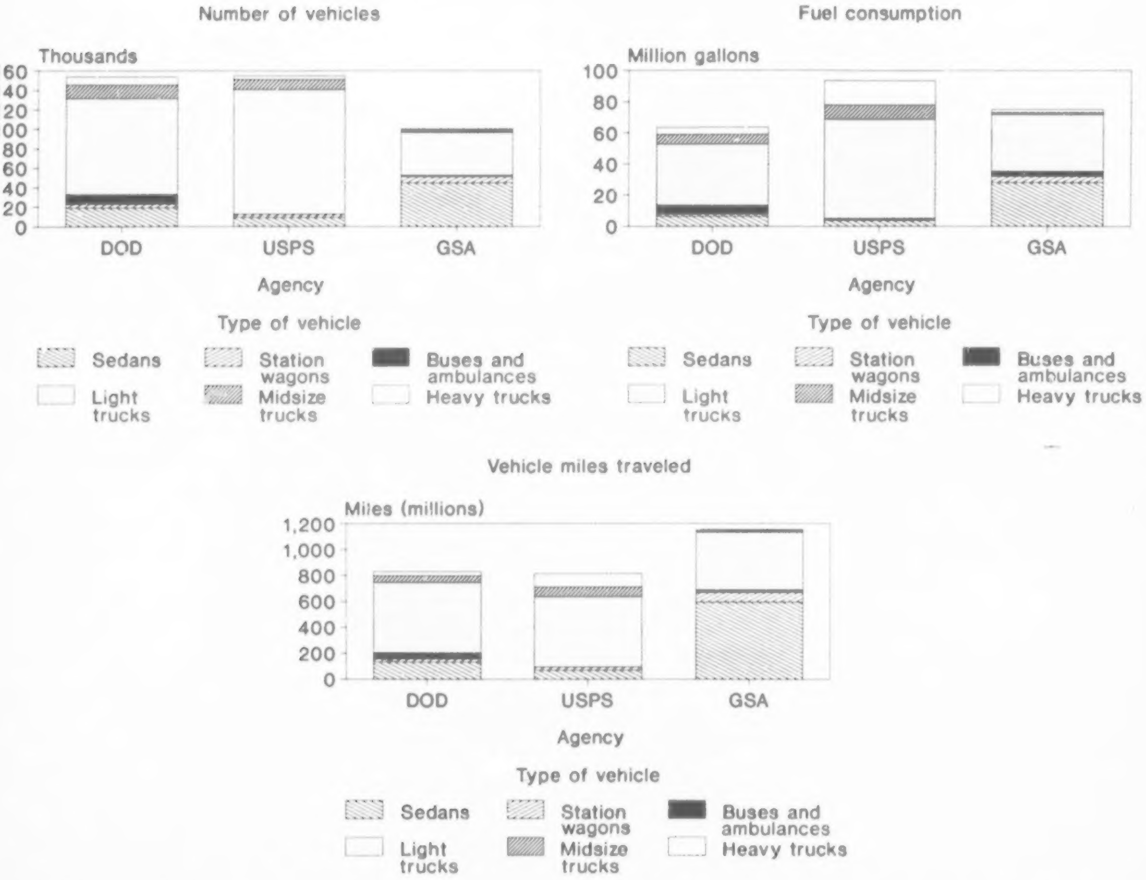
[4] U.S. Bureau of the Census, *Statistical Abstract of the United States: 1990*, 110th ed. (Washington, DC: 1990), tables 1028 and 1029.

[5] Sean Allen, Director, GSA Fleet Management Division, personal communication, Nov. 14, 1990; and Larry Frisbee, GSA Fleet Management Division, personal communication, Jan. 10, 1991.

[6] U.S. Department of Energy, op. cit., footnote 1, p. 53.

[7] U.S. General Services Administration, Office of Fleet Management, "Federal Motor Vehicle Fleet Report for Fiscal Year 1988," September 1990, tables 6 and 12. These figures account for only large domestic fleets, which make up 91.7 percent of total fleet.

Figure 4-3—Federal Fleet Data, Fiscal Year 1988



SOURCE: U.S. General Services Administration, Office of Fleet Management, "Federal Motor Vehicle Fleet Report for FY 1988," September 1990.

3) reduce the number of work-related trips, for example, through increased use of teleconferencing. All three are being pursued currently by the Federal Government, although it appears that additional efforts could produce further energy and cost savings without sacrificing productivity. In addition, use of electric vehicles and alternate fuels such as methanol and natural gas can be a way to decrease Federal consumption of petroleum products.[8] Although not inherently an energy conservation measure, use of alternate fuels could potentially reduce dependence on imported petroleum. As in the case with the Federal Government's owned and leased facilities, there appears to have been no coordinated governmentwide effort to identify the potential for further energy and cost savings in Federal light-duty vehicle fleet use beyond that required by the Motor Vehicle Information and Cost Savings Act and Executive orders.

Automobile Fuel Economy[9]

The variety of vehicles available in today's market is great. With hundreds of vehicles to choose from, fuel economy is only one of many distinguishing characteristics. The automobile with the highest rated estimated mileage by the Environmental Protection Agency (EPA) gets 55 combined miles per gallon (mpg). In any class, estimated mileage varies considerably. For compacts, the highest in the class rates an EPA estimate of 40 mpg; the lowest rates 15.5 combined mpg. In midsize cars, two models received 28 combined mpg, while several others received under 12 combined mpg.[10]

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[8] See U.S. Congress, Office of Technology Assessment, *Replacing Gasoline: Alternative Fuels for Light-Duty Vehicles*, OTA-E-364 (Washington, DC: U.S. Government Printing Office, September 1990).

[9] For a discussion of prospects for increased fuel economy of automobiles generally, see Steve Plotkin, "Improving the Fuel Economy of the U.S. Automobile Fleet," Testimony before the Subcommittee on Energy and Power, Committee on Energy and Commerce, U.S. House of Representatives, Oct. 1, 1990.

GSA is responsible for managing the Federal fleet and assuring that it is in compliance with Executive Order 12375, which requires the Federal passenger fleet to attain the Corporate Average Fuel Economy (which is 27.5 mpg for cars) and light trucks to attain 20.5 mpg from 1990 on as specified by the Secretary of Transportation (see ch. 2). Currently, the Federal automobile fleet has an average EPA mileage rating of 29.4 mpg (combined city and highway), 7 percent higher than the minimum requirement.[11]

The shift in the makeup of the Federal fleet to smaller, more fuel efficient cars has been one approach to securing a higher fleet average. The code of Federal regulations includes a mandatory provision stating that "all motor vehicles acquired for official purposes by executive agencies shall be selected to achieve maximum fuel efficiency and limited to the minimum body size, and optional equipment necessary to meet agencies' requirements."[12]

Further increases in economy of the Federal fleet appear possible. For example, GSA's Automotive Commodity Center has contracted to purchase 13,000 passenger sedans in 1991 with EPA-estimated mileage of 26 combined mpg, all with automatic transmission.[13] Other vehicles in the same class have better mileage ratings, including four domestically produced models which get 27 mpg with an automatic transmission. The manual transmission versions get 28 mpg.[14] However, performance, safety, first cost, and resale value all differ between the models, and must be considered in any assessment of life-cycle costs.

Although sedans with manual transmissions have about 4 percent higher fuel economy, sedans in the Federal fleet use automatic transmissions. An effort by GSA to promote manual transmission models resulted in excessive vehicle repairs, primarily to clutches.[15] This is not surprising since many drivers of the Federal fleet are used to automatic transmissions in their own cars.

Maintenance and Driver Training

How an individual drives a vehicle can impact on the mileage that vehicle achieves. Operator training brochures and courses are offered by the Federal Government that encourage better driving habits, although results of these efforts are difficult to measure. Recommendations include steps like: avoid unnecessary idling, anticipate stops, avoid "jack rabbit" starts, and avoid speeds over 55 mph.[16] Each of these steps raises drivers' awareness to fuel efficient operation of their vehicles.

Regular maintenance can also affect the efficiency and operation of the vehicle. Examples of items that can affect fuel economy are dragging brakes, low transmission fluid levels, out-of-tune engine, poor tire pressure, and old, plugged fuel or air filters. Fleet maintenance programs in the Federal Government are intended to meet manufacturer standards, and GSA has had a computerized system to track and encourage preventive maintenance since 1985.

Teleconferencing

Many Federal employees travel regularly and extensively for meetings. Teleconferencing offers the opportunity to have meetings without the time and expense of traveling. Though it is only appropriate in certain circumstances, teleconferencing offers real possibilities for many of today's meetings in the Federal Government. There are both energy and

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[10] U.S. Environmental Protection Agency, "1991 Fuel Economy Guide," Sept. 25, 1990.

[11] U.S. General Services Administration, Automotive Commodity Center, "1991 Federal Standards for Automobiles, Light Trucks, and Medium Trucks," October 1990, p. iv.

[12] 41 CFR 101-38.101-2 (July 1, 1990 Ed.).

[13] Larry Frisbee, GSA Fleet Management Division, personal communication, Jan. 10 and Jan. 31, 1991.

[14] U.S. Environmental Protection Agency, op. cit., footnote 10.

[15] Larry Frisbee, GSA Fleet Management Division, personal communication, Jan. 31, 1991.

[16] U.S. Environmental Protection Agency, "Tips for Fuel Efficient Driving," October 1990, p. 1.

Photo credit: VideoTelecom Corp.

Video-teleconferencing is increasingly being used as an alternative to travel, saving employee time, travel expenses, and energy.

nonenergy benefits. In fact, energy savings may be only a fraction of the value of time saved by Federal employees through teleconferencing. Teleconferencing can reduce not only Federal fleet use, but also the Federal use of air travel.

In 1985 GSA issued a "Federal Information Resources Management Regulation Bulletin on Travel by Federal Telecommunications System," stating:

> Travel is expensive in terms of time, energy, and money. This bulletin briefly describes telecommunications services provided by the Federal Telecommunications System (FTS) that can be used instead of travel to promote and encourage governmentwide savings.[17]

The most advanced systems combine video-teleconferencing, which allows face to face meetings, with data networks that allow transfer of documents during a meeting. In the past 18 months, significant strides have been made in making video-teleconferencing high-quality and cost-effective, because of anticipated international standards and a continuing steep downward cost curve.[18]

Some Federal agencies, including the National Aeronautics and Space Administration and DOD, currently have their own video-teleconferencing systems in place, and GSA offers video-teleconferencing for lease to all agencies through its Federal Telecommunications Service.[19] These systems are gaining use in the Federal Government (see table 4-1). For example, EPA has a system linking its headquarters in Washington, DC with its office in Research Triangle, North Carolina. The system's cost was $150,000.[20] GSA expects a continued drop in system costs over the next 18 months. Based on the successful results to date, EPA is expanding to an additional eight regional office sites. USPS inaugurated a $10-million satellite system with over 73 locations in December 1990. The two-way network was created to provide training and deliver messages to thousands of managers and employees. Assistant Postmaster General Elwood Mosley said, "This allows us to get to a large segment of the postal population quickly without bringing them to a central location. It's a very efficient, effective method to get information out to the field."[21] The system is expected to pay for itself within 4 years.

The cost of operating a video-teleconferencing system, once installed, depends on the price of accessing the high-speed transmission lines required. This price has dropped from about $1,000 an hour in the mid-1980s to about $15 an hour in 1990.[22]

Alternative Fuels and Vehicle Design

Several experimental programs with alternative fuel vehicles are underway. The USPS has a growing number of compressed natural gas trucks, in addition to 67,000 fuel efficient long-life vehicles and over 6,000 diesel delivery vans. DOE and GSA are purchasing a small number of alcohol fuel-flexible vehicles and natural-gas-powered light trucks as required by the Alternative Motor Fuels Act.[23] The Interagency Fleet Management System is currently

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[17] Frank J. Carr, Assistant Administrator for Information Resources Management, U.S. General Services Administration, FIRMR Bulletin 16, "Travel by Federal Telecommunications System," Jan. 28, 1985.

[18] Matt Kramer, "Teleconferencing: Meeting the 1990's Head-on," *PC Week*, Apr. 9, 1990, vol. 7, No. 14, p. 57(1).

[19] John Deluccha, U.S. General Services Administration, personal communication, Nov. 28, 1990.

[20] S.A. Masud, "EPA Offices To Cross Distances With Trial of Videoteleconferencing," *Government Computer News*, Nov. 27, 1989, vol. 8, No. 24, p. 3(1).

[21] Mark Kodama, "Training via Television: Satellite System Gets the Word Out," *Federal Times*, Dec. 31, 1990, p. 13.

[22] Paul B. Carroll, "VideoPhones: Picture Looks Brighter at Last," *Wall Street Journal*, Aug. 13, 1990, p. 1.

[23] Linda G. Stuntz, Deputy Undersecretary for Policy, "Statement on H.R. 5521—The National Energy Policy Act of 1990," Sept. 13, 1990, p. 2.

Photo credit: Grumman Corp.

One of the U.S. Postal Service's growing fleet of long-life vehicles.

Table 4-1—Partial List of Agency Teleconferencing Facilities

Agency	Sites	Type of network
National Oceanic and Atmospheric Administration[1]	18	Data
National Weather Service[1]	NA	Data
Secret Service[1]	10	Data, video
U.S. Army[1]	100	Video
U.S. Department of Agriculture[1]	300	Data
U.S. Department of the Interior[1]	80	Data
U.S. Environmental Protection Agency[2]	11	Video
U.S. Postal Service[3]	73	Video

SOURCES: [1] Satellite Communications as reported by Datapro Research *Satellite Communications: Technology Briefing*, MT20-620-101 (Delran, NJ: McGraw Hill, Inc., 1989), pp. 2-3.

[2] John DeLuccha, U.S. General Services Administration, personal communication, Nov. 28, 1990.

[3] Mark Kodama, "Training via Television: Satellite System Gets the Word Out," *Federal Times*, Dec. 31, 1990, p. 13.

operating 25 methanol flexible fuel sedans with an additional 40 such vehicles to be placed in service in the near future. In addition, a procurement is underway for light trucks fueled by compressed natural gas. DOE's Alternative Fuels Utilization Program has had a Methanol Fleet Project underway since 1985. An interim report found that energy efficiency in the methanol vehicles is slightly greater than the counterpart gasoline vehicles, but the alternative vehicles have required more service.[24] Development of electric delivery vans by domestic auto manufacturers, and improvements in electric vehicle batteries are continuing with support from the Electric Power Research Institute and may also be of use in certain applications in the Federal fleet.[25]

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[24] R.N. McGill and S.L. Hillis, *Results From the Second Year of Operation of the Federal Methanol Fleet at Lawrence Berkeley Laboratory*, ORNL/TM10815 (Oak Ridge, TN: Oak Ridge National Laboratory, August 1989).

[25] See Electric Power Research Institute, *Electric G-Van*, EPRI EU.2019.5.89R (Palo Alto, CA: 1989); and Electric Power Research Institute, *The Chrysler Electric TEVan*, EPRI EU.2022.11.90R (Palo Alto, CA: 1990).

Chapter 5

Six Case Studies

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Chapter 5

Six Case Studies

INTRODUCTION AND CASE STUDY METHODOLOGY

As part of its examination of opportunities for increased energy efficiency in the Federal Government, OTA conducted case studies of six diverse facilities.[1] Four are government owned and occupied, the fifth is a privately owned building leased to the Federal Government, and the last is a federally assisted housing authority.

Each case study examined two main topics: 1) current energy use and the opportunities for increased efficiency; and 2) the institutional, budgetary, economic, and technical reasons why apparently attractive energy conservation options were not being pursued.

The methodology used in the case studies relied heavily on the experiences of facility managers and any available facility energy analyses that had already been performed. OTA contracted with Enviro-Management & Research, Inc. (EMR), a consulting engineering firm, to conduct the case studies. Each case study included both on-site visits and telephone and mail correspondence. Table 5-1 lists the type of information and data collected.

EMR reviewed and analyzed all information collected on each case study facility. **Only commercially proven and very highly cost-effective measures having a payback period of less than 3 years were considered.**[2] Also, only more efficient equipment or improved operations and maintenance practices were considered. Approaches which require change in occupant comfort or productivity were not considered. Efficiency measures were divided into three categories: no cost, low cost, and significant cost. No cost measures involve virtually no cost to the facility as they can be implemented by in-house personnel. Low cost measures likewise can be implemented for the most part by in-house personnel, but necessitate some expenditures for materials and equipment required for the retrofit.

CONCLUSIONS: OPPORTUNITIES FOR FURTHER ENERGY AND COST SAVINGS

Three main conclusions are true of all of the case studies. First, there appears to be a large potential for savings. At these six federally owned, leased, or assisted facilities, an average savings of over 25 percent in annual operating cost and energy use appears achievable with proven and highly cost-effective technologies and operating strategies according to facility personnel. OTA's sample was small and not necessarily representative of the opportunities available in the overall Federal Government. However, it should be noted that two of OTA's case study subjects are Federal Energy Efficiency award winners. That is, these facilities and their personnel have made considerable, note-

Table 5-1—Information Collected From Case Study Sites

- General description of existing facilities, systems, and equipment
- Current energy use by type of fuel and major end-uses
- Major trends affecting energy use (e.g., increasing use of personal computers in offices; use of energy-intensive medical equipment such as computerized tomography scanners in hospitals; change in facility's mission; higher occupant density in offices)
- Major operational or equipment changes undertaken since 1980 to increase energy efficiency
- Planned modifications to building systems and equipment
- Experience with implementation of energy efficient technologies
- Energy and cost savings achieved due to implementation of energy conservation measures
- Impediments (institutional, budgetary, economic, and technical) affecting implementation of energy conservation efforts
- Perceived incentives for energy conservation
- Priority given to energy conservation in agency's mission
- Technical and economic criteria used for assessing energy conservation options
- Estimates of time it takes from initial study to final implementation of energy conservation options

SOURCE: EMR, "Case Study of Federal Building Energy Use," contractor report prepared for the Office of Technology Assessment, December 1990.

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[1] This chapter is adapted from Enviro-Management & Research, Inc., "Case Study of Federal Building Energy Use," contractor report prepared for the Office of Technology Assessment, December 1990.

[2] Because so many energy efficiency opportunities in the Federal Government are currently untapped, this study focuses only on those which are very highly cost-effective. However, it does not intend to suggest that a very high discount rate is appropriate in analyzing Federal energy efficiency opportunities. See ch. 1, box 1-A.

worthy achievements in energy efficiency not generally found throughout the government. Thus, it is reasonable to believe that greater savings are possible than indicated by this limited sample. Again, note that the case study estimates included only extremely cost-effective options in which the capital costs and other costs of implementation are small compared to the savings, with simple paybacks of under 3 years. A less stringent economic test that is more consistent with the cost of capital in the United States would produce higher estimates of potential energy and cost saving.

Second, there remains considerable uncertainty about the true extent of efficiency opportunities at the case studies. None of the facilities had performed a detailed energy audit of all their systems and operations within the past decade. Documentation and inventories for building systems and equipment and related energy conservation options were also often lacking. As a result, detailed, independent analysis of financial and economic characteristics of major options could generally not be performed. Ideally, analysis would include a review of financial, economic, and performance characteristics (e.g., capital costs, operating savings, performance improvements, return on investment (ROI) or payback) for all major options. Instead, the applicability and economic performance of various options were estimated based on the professional judgment of the facility managers and EMR.

Third, there is a variety of constraints to improved energy efficiency at the facilities. Funding or staffing constraints are common and important, but low priority, lack of incentives, and other factors are also noted by facility personnel.

CASE STUDY 1: GSA, SUITLAND COMPLEX, SUITLAND, MD

General Services Administration's (GSA) Suitland Complex comprises five major buildings occupied by the National Archives and Records Administration, Naval Intelligence, Census Bureau, and National Oceanic and Atmospheric Administration. The total building area in the Complex is approximately 2 million square feet.

Current Energy Use

The total annual energy expenditures are about $5 million. Several different energy sources are used in the Complex, including electricity, natural gas, and oil. Electricity is the dominant form, accounting for over 90 percent of expenditures. It is used for lighting, comfort conditioning, computer room air-conditioning, and electrical equipment. Natural gas and oil are used for space heating, service water heating, and cooking.

Energy consumption and cost data for the Complex since 1985 are shown in figure 5-1. Electricity consumption has increased by about 26 percent since 1985 due to a variety of factors as discussed below. Natural gas consumption has decreased by more than 50 percent, reflecting the effects of changing weather conditions, energy conservation efforts, and cutback of gas supplies because of participation in a curtailable service program. With regards to the latter, oil consumption, which is very low, has fluctuated because all heating equipment used oil during periods of natural gas curtailment.

Factors Affecting Energy Use

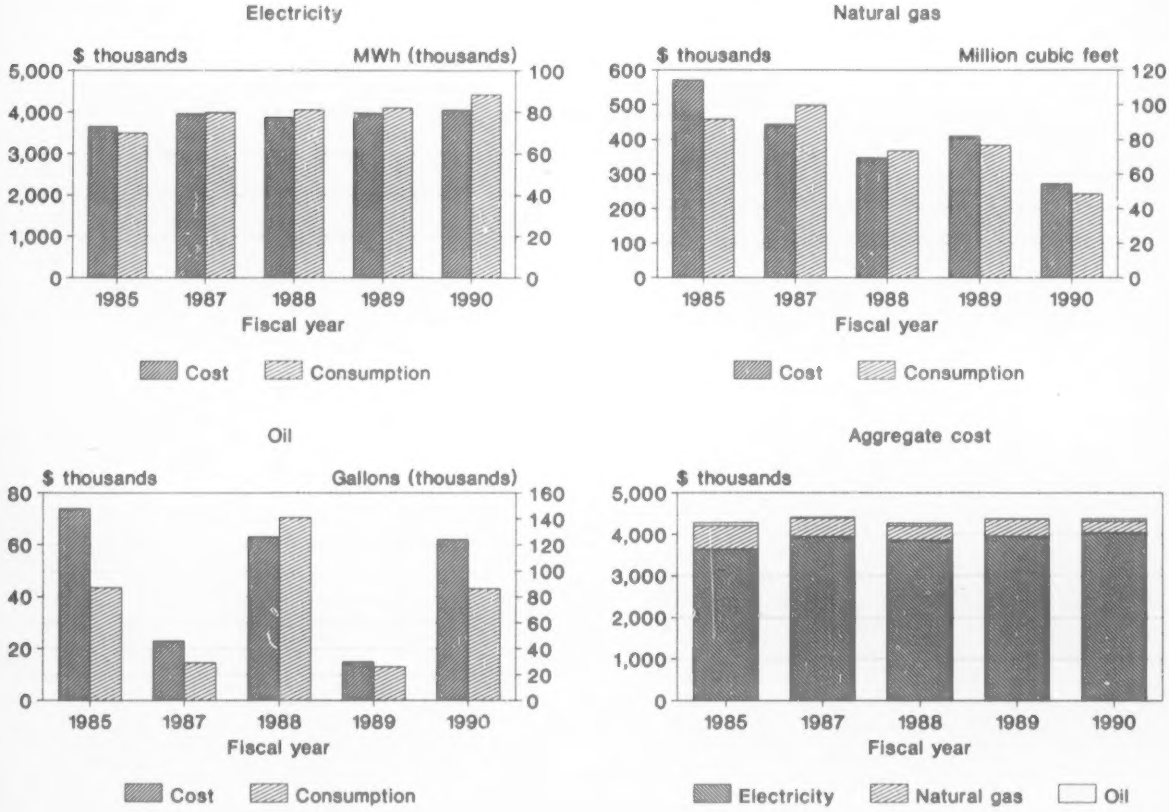
Several changes causing greater energy use are occurring at the Complex:

- More people are working at the Complex. In the past, space allocation was 200 square feet per person. It now is down to 135 square feet per person, and the new goal is 122 square feet per person.
- More computer equipment is being used in computer rooms and offices.
- Office and storage space has been converted to computer rooms.
- Network computers are always left on because of the growing use of electronic mail.
- More building space is being added to the Complex. A 17,000-square-foot addition was built for the NIC 2 Building and a 5,000-square-foot conference center will be completed in 1991. The master plan calls for approximately 1 million square feet of additional space at the Complex.

Energy Conservation Efforts to Date

Many energy efficiency improvements have been implemented at the Complex since 1980 because of personal interest taken by field office personnel. Most of these improvements involved no cost/low

Figure 5-1—Suitland Complex Energy Data



SOURCE: EMR, "Case Study of Federal Building Energy Use," contractor report prepared for OTA, December 1990.

cost options because funding for capital-intensive projects was not readily available. Energy conservation was given low priority, while more attention was focused on other concerns such as asbestos removal, fire safety, health issues, and transformers containing polychlorinated biphenyls (PCBs). Since 1987, however, emphasis on energy conservation has increased substantially due to the new programs initiated by the chief of the energy management section at the National Capital Region (NCR) office and commitment of personnel at the field office. The field office manager is enthusiastic and thorough in finding and trying new energy- and cost-saving measures, and received a Federal Energy Efficiency Award in 1990.

Many measures are actively being considered or currently being implemented (see table 5-2) at the Complex due to joint efforts between the NCR and the field staff. Furthermore, GSA has created a special energy management fund for implementing energy conservation projects. Currently, $30 million has been allocated for fiscal year 1991, one-third of which will be spent on lighting energy conservation retrofits in the NCR.

Energy Conservation Potential

Many cost-effective energy conservation measures have yet to be implemented at the Complex. Thus, a significant potential for further energy conservation still exists. The field office manager estimated that up to 20-percent reduction in energy use can be achieved if the following measures were implemented:

- Replace existing ballasts with higher efficiency electronic ballasts.

Table 5-2—Conservation Measures Implemented to Date at Suitland Complex

Increase efficiency of heating, ventilating, and air-conditioning systems

Maintain systems for efficiency:

Adjusted air dampers for tight closing.
Adjusted fuel-air ratio, fuel temperature at burner tip.
Sealed air leaks into combustion chamber.
Adjusted pumps to control leakage at pump packing glands.
Checked flues and chimney for blockages or improper draft conditions.
Clean filters and heat transfer surfaces.
Clean strainer screens in pumping systems.
Keep maintenance and operating log of all heating equipment.
Maintain correct refrigerant charge to avoid excessive compressor operation.
Recalibrated all controls.
Repair faulty steam traps and valves.
Repair leaks in chilled water, condenser water and conditioned air distribution systems.
Repaired insulation on economizers, condensate receiver tanks, boilers, furnaces, etc.
Use proper water treatment to reduce fouling of heat transfer surfaces in boilers, heat exchangers, etc.

Operate systems efficiently:

Do not permit perimeter and interior systems to buck one another.
Eliminate or reduce use of HVAC systems which require simultaneous heating and cooling.
Operate only necessary heating water pumps.
Operate only the chilled water pump and cooling tower fans as necessary.
Operate return-air fans for heating during unoccupied hours.
Optimize ventilation startup times.
Vary temperature of supply air, heating water and chilled water, and pressure of steam in accordance with load.
Recover heat from condensate.
Reduce generating and storage temperature levels to the minimum required.
Use outdoor air for economizer cooling.
Use spot cooling of people when they were located far apart.
Use minimum number of chillers and boilers. (More efficient to operate one unit at 90% than two at 45%.)
Use lowest possible radiation temperature in perimeter spaces.
Lower indoor temperature and relative humidity during heating season as practical.
Operate ventilation and exhaust systems only when needed (e.g., at a minimum during unoccupied hours).
Turn off cooling system during unoccupied hours in noncritical areas.
Reduce cooling/heating in over-cooled/-heated spaces.
Locked thermostats to prevent resetting by unauthorized personnel.

Upgraded equipment to allow efficient operation:

Added valves, dampers and controls to set back temperatures during unoccupied periods in noncritical areas.
Added automatic draft damper control to reduce heat loss through breaching when the gas or oil burner in not in operation.
Installed automatic ventilation controls.
Installed warmup cycle controls on air handling units with outside air intake as applicable.
Installed time clocks on self-contained cooling units for automatic shutoff.
Installed automatic temperature control valves in radiators controlled by hand valves.
Insulated steam lines, above and below ground.
Insulated chilled water piping and duct work carrying conditioned air through unconditioned spaces.
Provided additional thermostats for better control of heating equipment.
Replaced inefficient window air conditioners.
Isolated off-line chillers and boilers.
Installed boiler stack economizer for preheating feed water.[b]
Recirculated exhaust air using activated charcoal filters in noncritical areas.[b]
Replaced existing boilers which are not at or near the end of their useful life with modular boilers.[b]

Improve the building envelope

Added additional insulation to roofs, ceilings and floors over unconditioned areas.
Added reflective films to reduce solar heat gain.
Established rules for all building personnel to keep doors and windows closed when heating or cooling system is operating.
Installed weatherstripping around windows and doors.
Installed an air curtain at loading dock.
Installed automatic door closers on exterior doors.
Rehung misaligned exterior doors.
Replaced broken windows.
Used opaque or transluscent insulating materials to block off and thermally seal all unused windows.
Used vestibules and/or revolving doors to reduce infiltration.[b]

Improve lighting efficiency:

Reduce unneeded illumination:

Installed photocell or time controls to operate outdoor lighting.
Installed occupancy sensors in hallways and other areas.
Installed timers to control lights in closets.
Reduced illumination to levels consistent with productivity, safety and security considerations.
Removed unnecessary lamps when those remaining can provide desired illumination.
Relocated luminaires to provide light on task areas.
Use daylighting for illumination in perimeter areas as practical.

Increase efficiency of lamps, ballasts and fixtures:

Used more efficient ballasts.
Use light colors for walls, floors and ceilings to increase reflectance but avoid specular reflections.
Use high-efficiency fixtures.
Clean lamps, luminaires and interior surfaces.
Lowered height of lighting fixtures.
Used higher efficiency lamps.[b]

Miscellaneous

Boost hot water temperature locally.
De-energized booster heaters in kitchens at night.
De-energized hot water circulating pumps when building is unoccupied.
Examined elevator usage; shut down excess capacity.
Improved maintenance of motors.
Installed and maintained insulation on all hot water pipes, fittings and valves passing through unconditioned spaces.
Insulated hot bare pipes and storage tanks.
Installed efficient nozzles and faucets.
Located water heater close to point of use.
Turned off infrared food warmers when no food is being warmed.

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[a] Unless otherwise noted, all measures are considered by facility personnel to be low cost or no cost.

[b] Significant cost measure as identified by facility personnel.

SOURCE: Adapted from Enviro-Management & Research, "Case Study of Federal Building Energy Use," contractor report prepared for the Office of Technology Assessment, December 1990.

- Replace the existing energy management system with a new system employing direct digital controls. Include optimizing functions on all air handling units and chillers.
- Convert constant air volume systems to variable air volume systems. In conventional buildings employing constant air volume systems, the quantity of air heated or cooled remains the same regardless of the heating or cooling requirements of the area or zone served. The energy waste which results can be almost eliminated by converting to variable air volume systems fitted with adjustable speed fan controls which throttle down conditioned air supply to each area or zone to meet the changing load requirements.
- Replace oversized motors with energy efficient motors. Most motors are oversized for the equipment loads served. The degree of oversizing increases when building loads are reduced through application of various energy conservation opportunities. Motors that are not loaded to at least 60 percent of their potential are inefficient. They should be replaced with energy efficient motors, which are about 8 percent more efficient than the models in use at the facility.
- Use variable speed pumping. The design of chilled water pumps requires that sufficient capacity be installed for "design" cooling load. However, "design" load conditions exist only a small percentage of the time, whereas a reduced load and reduced pumping capacity exist most of the time.
- Eliminate all unnecessary exhaust hoods and roof ventilators. The air which is exhausted must be made up by outside air which usually is conditioned. This creates significant energy waste. Correcting the problem can create substantial savings.
- Reduce infiltration and exfiltration through openings in building envelope. Both infiltration and exfiltration place a burden on the heating and cooling systems, much as ventilation does. When conditioned air leaks out, it is made up of indoor air which must be conditioned. When outdoor air leaks in, it must be conditioned, too.
- Install economizer cycle controls. The savings provided by an economizer cycle can range from 10 to 60 percent of current cooling energy costs, depending upon the type of building and heating, ventilating, and air conditioning (HVAC) system involved.
- Balance chilled water and air distribution systems. Balancing assures that only the proper amounts of conditioned water or air are supplied to each zone. This minimizes energy used by the cooling system while simultaneously providing greater comfort.
- Reglaze windows with double or triple glazing. Double- or triple-glazed windows can reduce heat transfer by more than 50 percent, thus significantly lowering heating and cooling load which the HVAC system must meet.
- Reduce thermal losses and eliminate leaks in underground hot water and chilled water lines. Leaks can cause substantial energy waste. The value of such waste can be very large if left uncorrected. The underground hot water distribution system at the Complex is about 25 years old and needs repairing.
- Install automated demand limiting controls. Demand control can result in significant cost reduction by reducing a facility's electrical demand during peak periods. New microprocessor-based systems permit energy reduction as well because these systems can perform many more functions (e.g., optimized start/stop, duty cycling of motors, etc.) than just demand control systems.
- Reduce quantity of service hot water used. Installing flow reduction devices is one of the most effective techniques for reducing consumption of hot water. These devices include flow restricting orifices which are installed in the line, aerators which reduce flows and mix water with air, and self-closing hot water faucets.

Barriers to Energy Conservation

Several barriers have restricted full implementation of energy conservation measures at the Complex in the past. Some of these still exist. They are as follows:

- Inadequate procurement and clerical staff to implement energy conservation projects even though funding currently is available. This also limits the Complex in taking advantage of local utility incentive and rebate programs.
- Top agency management commitment to energy conservation has not been consistent. As an example, it was not until 1987 that energy

conservation gained greater acceptance and commitment from top agency management. A new chief of energy management was appointed at that time. Once on-board, the chief aggressively promoted energy conservation and initiated a range of new programs.

- Procurement policies limit acquisition of high-quality equipment, products, and services. According to the field office manager, "The Federal Government's policy of selecting small businesses and/or the lowest bidder does not necessarily result in quality equipment, products and services."
- Economic criteria used by GSA limits implementation of certain technologies which can result in significant energy savings but have long payback periods (more than 3 years).
- Substantial lag time (3 to 5 years) in acquiring and installing capital intensive equipment and lack of follow-through. For example, it took 3 years to acquire an energy management system and an additional 2 years to install. After completion, the system never worked because it was installed improperly.
- Some new energy conservation technology is too sophisticated for building operators to understand and operate. As an example, the lighting controls for certain outdoor lighting is so sophisticated that most of the mechanics at the Complex are unable to understand or properly operate these devices.
- Lack of funds for personnel training in energy conservation. Although some funds are available, these have been allocated for training in other areas, such as asbestos management and removal.
- Policies that restrict replacing equipment that is still operating but is outdated and inefficient. As an example, the Complex still employs many motors that were installed in the 1950s. Because they still are operating, no funds are available for replacing them with energy efficient motors.

CASE STUDY 2:
VA MEDICAL CENTER, WASHINGTON, DC

Built in 1962, the U.S. Department of Veterans Affairs (VA) Medical Center currently comprises 870,000 square feet of hospital, nursing home, research, and other medical care facilities.

Current Energy Use

A variety of energy sources are used at the VA Medical Center with electricity comprising over 90 percent of spending. Electricity is used primarily for space cooling, ventilation, lighting, cooking, and other electrically driven equipment and machinery. Other energy sources are used for the following applications: fuel oil for emergency generators, vehicles, and tractors; natural gas for cooking and laboratory bunsen burners; gasoline for VA-owned vehicles and equipment; and purchased steam for space heating and service water heating. Energy consumption data for the most recent 12 months is shown in table 5-3.

Factors Affecting Energy Use

Many of the building systems used in the Center are relatively inefficient by today's standards (e.g., lighting systems designed to provide 150 foot-candles in administrative areas, air handling systems designed for 100 percent outside air even in administrative areas, and use of dual duct systems). This is because several of the Center's buildings were built at a time when energy was relatively cheap and energy conservation standards did not exist.

Although the Center has implemented a range of energy conservation measures, the following new situations have resulted in increased energy consumption for space conditioning, lighting, service water heating, and other support equipment critical to the mission of the Center:

- Personal computers are being used increasingly in administrative areas.
- Energy-intensive medical equipment such as nuclear magnetic resonance scanners is being used increasingly for personal care and diagnostics.
- Occupancy levels are the highest they have ever been.
- Patient care and administrative activities at the Center have substantially increased in recent years.
- Construction of new facilities has added more square footage to the Center. As examples, Building 4 was added in 1973 and a nursing home was built in 1985.
- New mechanical and electrical equipment has been added to the Center in support of new and expanded facilities since 1973.

Table 5-3—U.S. Department of Veterans Affairs Medical Center Energy Consumption, July 1989 to July 1990

Energy source	Energy consumption
Electricity	181,588,000 kWh
Fuel oil	7,933 gallons
Natural gas	2,584,900 cubic feet
Gasoline	8,475 gallons
Purchased steam	88,168,150 pounds

SOURCE: EMR, "Case Study of Federal Building Energy Use," contractor report prepared for the Office of Technology Assessment, December 1990.

Energy Conservation Efforts to Date

The Center has implemented a variety of energy conservation measures since the 1973 oil embargo which dramatically increased the cost of energy. Although the Center has no formal energy management program, it has implemented a range of energy conservation measures to date as part of its continuing maintenance program. The funding for past and ongoing energy conservation efforts has been derived from the nonrecurring maintenance budget. Table 5-4 summarizes the various energy conservation measures that have been implemented to date. Although some of the measures represent one-time efforts (e.g., rehanging misaligned exterior doors and providing additional thermostats for better control of heating equipment), most measures are being implemented on a continuing basis (e.g., shut off exhaust systems when not needed and reset heating water temperature in accordance with load). Most of these are no cost/low cost measures.

Energy Conservation Potential

Although these energy conservation efforts have resulted in some energy savings and reduced cost, the potential for further energy and cost savings remains high. Because the Center has to date implemented mostly no cost/low cost measures, a significant potential for further energy and cost savings still exists. It is estimated by engineering and operating personnel at the facility that up to a 30-percent reduction in energy use can be achieved if the following measures are implemented:

- Reduce illumination in various spaces to levels consistent with American Society of Heating, Refrigerating, and Air-Conditioning Engineers (ASHRAE) Standard 90 (e.g., reduce from 150 foot-candles to 75 foot-candles in administrative areas).
- Replace all existing fluorescent lamps with higher efficiency fluorescent lamps.
- Replace existing ballasts with higher efficiency electronic ballasts.
- Replace incandescent lamps with compact fluorescent lamps as appropriate.
- Replace existing mercury vapor lamps with high-pressure sodium lamps for exterior lighting.
- Add controls (timers, motion detectors, dimmer switches, daylighting controls, etc.) as appropriate to turn off lighting during noncritical periods (e.g., 8 p.m. to 5 a.m.) in hallway corridors and unoccupied areas.
- Add controls to turn off all lighting in the parking garage of the nursing home when not needed.
- Replace existing energy management system with new system employing direct digital controls. Include optimizing functions on all air handling units and chillers.
- Convert remaining constant air volume systems to variable air volume systems.
- Use adjustable speed drives for variable fan speed control.
- Replace all motors above 40 hp with energy efficient motors.
- Use variable speed pumping during light loads.
- Use an active solar system for heating in the swimming pool, which currently consumes one-third of total purchased steam in the winter and one-half of total purchased steam in the summer.

Barriers to Energy Conservation

Despite the past energy conservation efforts at the Center, many barriers and constraints still must be overcome in order to achieve further energy and cost savings. These are as follows:

- Relatively low priority is given to energy conservation because energy expenditures constitute a very small percentage of the overall Center budget. Medical care and safety and health-related projects (e.g., asbestos and PCB removal) are given a much higher priority. Because of the nature of the Center's mission, patient care is accorded the highest priority. According to the assistant chief of engineering, "If a doctor needed a new piece of machinery to do a scan, that machinery will be bought before any engineering projects are even con-

Table 5-4—Conservation Measures Implemented to Date at VA Medical Center[a]

Increase efficiency of heating, ventilating, and air-conditioning systems

Maintain systems for efficiency:
Adjusted dampers in mixing boxes and multizone units to reduce leakage.
Adjusted pumps to control leakage at pump packing glands.
Checked refrigeration systems for correct refrigerant charge to avoid excessive compressor operation.
Clean filters, heat transfer surfaces and combustion surfaces.
Use proper water treatment to reduce fouling of transfer surfaces in chillers, boilers and heat exchangers.
Corrected improper automatic control operation.
Keep maintenance and operating log of heating equipment.
Maintain all cooling equipment.
Repaired insulation and leaks on economizers, condensate receiver tanks, boilers, furnaces, etc.
Sealed all air leaks into combustion chamber.
Use low resistance filters, registers and grilles to reduce horsepower required for air movement.

Operate systems efficiently:
Eliminate or reduce use of HVAC systems which require simultaneous heating and cooling.
Use minimum number of chillers; isolate off-line units.
Locked thermostats to prevent resetting by unauthorized personnel.
Lower indoor temperature and relative humidity during heating season.
Operate condenser water system at lower temperature.
Operate only the chilled water pump and cooling tower fans as necessary.
Operate only necessary heating water pumps.
Recover heat from condensate.
Reduce generating and storage temperature levels to the minimum required.
Reduce fan speed and hours of fan and pump operation.
Turn off cooling system and reduce ventilation rates during unoccupied hours in noncritical areas.
Use lowest possible radiation temperature in perimeter spaces.
Use outdoor air for economizer cooling.
Use spot cooling of people when they were located far apart.
Vary temperature of heating water, chilled water and supply air, and pressure of steam in accordance with load.
Close off unused areas and rooms.
Do not cool lobbies, passageways and storage areas to same degree as work areas.
Increase indoor temperature and relative humidity levels during cooling season as practical.
Reduce cooling in over-cooled spaces.

Upgraded equipment to allow efficient operation:
Added heat recovery on all computer room cooling units.
Added heat recovery coils on major exhaust systems.[b]
Added heat recovery coils on major dual duct air handling units.[b]
Added controls to setback temperatures during unoccupied periods in noncritical areas.
Converted constant-volume fan system to variable air volume.
Eliminated unnecessary exhaust hoods and roof ventilators.
Installed economizer cycle.
Installed and maintain insulation on all hot water pipes, fittings and valves passing through unconditioned spaces.
Installed valves and dampers to permit shutoff of heating in unoccupied areas where there is no danger of freezing.
Installed energy management control system.[b]
Insulated all steam lines, above and below ground.
Insulated all duct work carrying conditioned air through unconditioned spaces.
Insulated chilled water piping and ductwork located in unconditioned spaces.
Insulated hot bare pipes and storage tanks.
Provided additional thermostats for better control of heating equipment.
Replaced oversized hoods that removed excessive quantities of air.

Improve the building envelope

Improve building envelope:
Caulked all windows and door frames.
Established rules for all building personnel to keep doors and windows closed when heating system is operating.
Installed weatherstripping around windows and doors.
Installed loading dock door seals.
Installed automatic door closers on all exterior doors.
Reduced solar heat gain.
Reglazed windows with double glazing.
Rehung misaligned exterior doors.
Repaired cracks and openings in exterior surfaces.
Used vestibules and/or revolving doors to reduce infiltration.

Improve lighting efficiency:

Reduce unneeded illumination:
Added photocell or time controls to operate outdoor lighting.
Use light colors for walls, floors and ceilings to increase reflectance but avoid specular reflections.
Reduced illumination to levels consistent with productivity, safety and security considerations.
Removed unnecessary lamps when those remaining can provide desired illumination.
Used daylighting for illumination in perimeter areas as practical.

Increase efficiency of lamps, ballasts and fixtures:
Clean lamps, luminaires and interior surfaces.

Miscellaneous
Adjusted valves for minimal water use.
Boost hot water temperature locally.
Checked sterilizer and refrigeration equipment for proper gasketing and function. Repair or replac as necessary.
Inserted orifices in hot water pipes to reduce flow.
Installed efficient nozzles and faucets.
Installed demand limiting equipment.
Clean refrigeration condenser coils.
Recover steam condensate for service water heating.
Replaced sterilizers to reduce steam demand.
Replaced old steam cookers with new flask cookers.
Replaced selected motors with energy efficient motors.[b]
Turn off electrical appliances and machinery not being used.
Use water properly for grounds.

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[a] Unless otherwise noted, all measures are considered by facility personnel to be low cost or no cost.

[b] Significant cost measure as identified by facility personnel.

SOURCE: Adapted from Enviro-Management & Research, "Case Study of Federal Building Energy Use," contractor report prepared for the Office of Technology Assessment, December 1990.

sidered. However, if a circuit breaker in an electrical panel is operating in an unsafe manner, it also will be accorded a high priority for funding. . .''

- Lack of policy and direction on energy conservation from central office to top management at the Center. This is due in part to the low priority accorded to energy conservation by various VA administrators during the past decade, as well as the lack of available agency funding for energy retrofits and capital intensive improvements.
- Top management commitment to energy conservation has not been consistent. Some past hospital administrators have placed a greater emphasis on energy conservation than others.
- Lack of a comprehensive energy management program and an energy coordinator who would be responsible for implementation of such a program.
- Lack of internal incentives to conserve energy, both for staff and Center as a whole. Although the annual DOE Federal Energy Efficiency Awards recognize achievements of selected Federal energy managers, the availability of additional incentives for other agency personnel is nonexistent. Furthermore, if the Center does achieve energy cost savings, these savings cannot be used for future energy conservation projects, but are retained in the general utility fund by the central office.
- Limited availability of funding and the long lag time (3 to 4 years) in obtaining appropriations after the need for the money has been identified. This factor is becoming increasingly important because the Center has implemented many of the no cost/low cost measures, and mostly the significant cost projects remain.
- Not enough qualified staff to undertake energy conservation improvements. For this reason and because of limited availability of funds, the Center cannot benefit from the current utility rebate programs, particularly with respect to lighting.
- Lack of awareness of new energy conservation products and techniques because the Center does not reimburse engineering and operation staff for attending workshops and conferences or even becoming members of associations (American Society of Heating, Refrigerating and Air-Conditioning Engineers, Association of Energy Engineers, etc.) involved in energy-related fields.

CASE STUDY 3: SAN DIEGO DIVISION OF THE U.S. POSTAL SERVICE, CA

The San Diego Division of the U.S. Postal Service administers over 370 postal facilities located in two mail sectional centers (MSCs), one in San Diego and the other in San Bernadino.

Current Energy Use

Energy sources used at the Division include electricity, gasoline, and a small amount of natural gas. Electricity is used primarily for ventilation, space cooling (in inland facilities only), lighting, and by electrically driven mail processing equipment. Lighting systems account for about 40 to 50 percent of the total electricity consumed. Natural gas is used for space heating and water heating. Gasoline is the primary fuel used by the Division's vehicles.

Figure 5-2 summarizes annual building energy use for 1985, 1987, and the most current 12 months. Although energy conservation programs have resulted in reduced energy use, reductions have been offset by increased energy consumption due to several factors as discussed below.

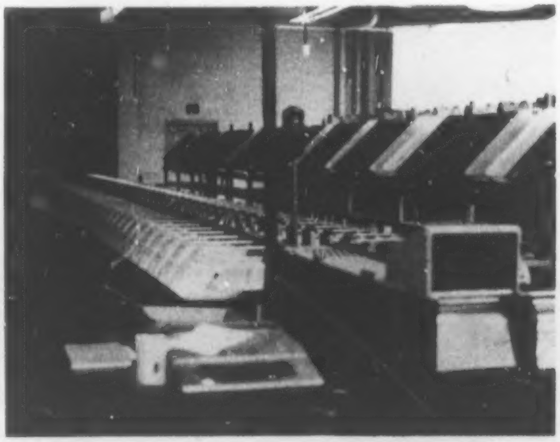
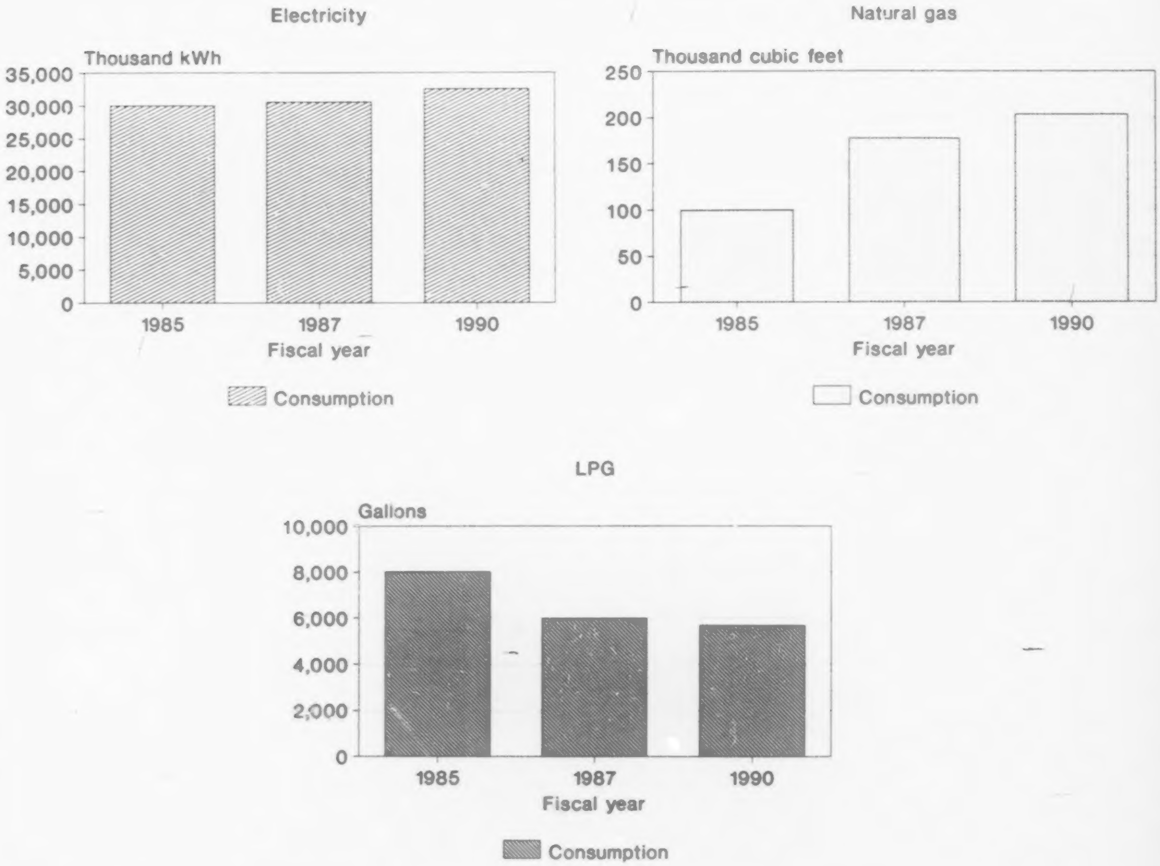


Photo credit: Robin Roy

Automated mail handling equipment improves service and reduces costs, but increases electricity use.

Figure 5-2—Energy Consumption at USPS San Diego Division, Fiscal Years 1985, 1987, and 1990



Electricity

Natural gas

LPG

SOURCE: EMR, "Case Study of Federal Building Energy Use," contractor report prepared for OTA, December 1990.

Factors Affecting Energy Use

Three factors are influencing greater energy use in the Division:

- New automated mail processing equipment (e.g., bar-code sorters, optical character readers, letter sorting machines, and flat sorting machines) is being added fairly rapidly to central facilities as well as large and associate post offices. The goal throughout the U.S. Postal Service is 100 percent bar-coded mail by 1995.
- Increased automation in certain facilities is necessitating the use of air conditioning to control humidity at levels conducive to the operation of the automated mail processing equipment.
- New and expanded facilities are adding more square footage and additional energy using support equipment under the control of the Division.

Energy Conservation Efforts to Date

The Division has had a successful energy conservation program for several years. In fact, it received a national corporate energy award from the Association of Energy Engineers in 1990, and the energy coordinator at the facility was named energy manager of the year. The Division also won a 1990 Federal Energy Efficiency Award.

Energy conservation efforts at the Division date back to 1984 when a postmaster at one of the facilities took personal interest in energy conservation and obtained support from the general manager to initiate energy conservation programs at his facility. These efforts reduced that facility's energy use by 25 percent. Realizing the success of these efforts, the Division has encouraged other facilities to initiate similar energy conservation programs.

The Division general manager/postmaster is committed to energy conservation and management. One innovative action taken by the general manager several years ago involved the creation of a division energy coordinator's position. Once on-board, the new energy coordinator initiated the Federal Government's first shared energy savings (SES) contract to retrofit lighting at the San Diego General Mail Facility. According to the energy coordinator,

> The results to date have been impressive. Energy savings have far exceeded those projected. One reason for these huge savings is that the Division has been incredibly aggressive in the enforcement of this contract.

The primary focus of the energy conservation program to date has been retrofit of lighting systems.

In 1987, the Division negotiated a shared energy savings (SES) contract to retrofit lighting systems at the San Diego General Mail Facility comprising 398,626 total square feet of floor area, a few percent of the Division's total. The retrofit involved replacing 2,292 existing fluorescent lighting fixtures and their associated ballasts, and removing 992 others. It included installation of energy efficient magnetic ballasts, specular reflectors, and new 34-watt lamps. The retrofitted systems are now maintaining the same light levels with two lamps, instead of four lamps used in older systems with considerably less heat and energy consumption. The SES contract has not only met but has exceeded energy savings expectations of the Division to date.

Even though the SES contract has proven successful in reducing energy use, there are no plans to use SES again at the Division's other facilities because local utilities are providing substantial rebates of 40 percent or more for every dollar invested in retrofitting existing lighting systems with energy efficient lamps and electronic ballasts. Rebates are also available for a variety of other energy efficient equipment retrofits (e.g., high-efficiency space conditioning equipment, high-efficiency motors, daylighting controls). By using Postal Service investment funds and utility rebates rather than SES, the Division has been able to retain all the cost savings in several recently conducted lighting retrofits.

Some of the no cost/low cost energy conservation measures that have been implemented at various facilities to date are shown in table 5-5.

Energy Conservation Potential

Based upon the successful results of the SES project, lighting surveys have been conducted at all Division facilities larger than 3,000 square feet to determine the potential for additional lighting system retrofits. As shown in table 5-6, a significant potential for energy reductions still exists. Division personnel estimate that up to 35 percent reduction in energy use can be achieved if the following measures are implemented. Several of the lighting measures are being implemented in 1991 using Postal Service funds and utility rebates.

Table 5-5—Conservation Measures Implemented at U.S. Postal Service, San Diego Division

No cost/low cost measures:

Shut down ventilation systems during unoccupied periods in noncritical areas.
Reduced ventilation rates during unoccupied hours to a minimum in noncritical areas.
Turned off cooling systems during unoccupied hours in noncritical areas.
Raised chilled water temperatures in accordance with load.
Operated only chilled water pumps and cooling tower fans as necessary.
Reduced illumination to levels consistent with productivity, safety, and security considerations.
Added switching and timers to turn off lights when not needed.
Used daylight for illumination in perimeter areas as practical.
Removed unnecessary lamps when those remaining can provide desired illumination.
Established an effective lighting usage program.
Moved desks and other work surfaces to a position and orientation that will use installed luminaries to their greatest advantage.
Added photocell or time controls to operate outdoor lighting.
Used light colors for walls, floors, and ceilings to increase reflectance but avoid specular reflections.
Used more efficient ballasts.
Relocated luminaries to provide light on task areas.
Lowered height of lighting fixtures.

SOURCE: EMR, "Case Study of Federal Building Energy Use," contractor report prepared for the Office of Technology Assessment, December 1990.

Table 5-6—Summary of South County Lighting Retrofit Potential

Facility	Total fixtures	Total fixtures to be retrofit	Average rate	Annual kWh saved
1. Alpine	119	108	0.097	25,201
2. Andrew Jackson	193	132	0.086	36,461
3. Bonita	144	134	0.096	26,269
4. Rancho Del Rey	77	62	0.097	21,328
5. Chula Vista Main Office	164	153	0.078	38,346
6. City Heights Station	91	89	0.100	25,336
7. Coronado	121	105	0.093	32,394
8. Downtown Station	629	548	0.096	137,800
9. El Cajon Main Office	607	538	0.078	139,576
10. El Cajon Bostonia	166	154	0.087	63,182
11. Encanto Station	62	61	0.099	17,342
12. Fashion Valley	112	111	0.102	11,609
13. Hillcrest Station	261	218	0.100	57,581
14. Imperial Beach	82	98	0.096	9,201
15. Jamul	62	62	0.097	16,125
16. John Adams	65	67	0.101	18,487
17. Lakeside	106	96	0.098	18,885
18. La Jolla Annex	142	140	0.081	47,787
19. La Jolla Main Office	383	367	0.081	68,923
20. La Mesa Annex	83	69	0.098	17,079
21. Lemon Grove	204	172	0.082	44,857
22. National City	122	96	0.084	39,487
23. Navajo Sia	128	119	0.088	22,324
24. North Park	85	70	0.096	19,181
25. Ocean Beach	113	113	0.099	17,434
26. Pacific Beach	112	107	0.078	35,523
27. Point Loma	98	86	0.099	19,693
28. Santee	180	180	0.099	29,855
29. San Ysidro	185	133	0.086	25,932
30. Serra Mesa	144	135	0.082	36,033
31. South Eastern Station	60	58	0.099	14,181
32. Spring Valley	275	266	0.087	73,841
33. University Station	57	41	0.099	9,062
34. William Taft Station	213	161	0.088	53,306
Total	5,645	5,049	0.092	1,273,822

SOURCE: EMR, "Case Study of Federal Building Energy Use," contractor report prepared for the Office of Technology Assessment, December 1990.

- Retrofit lighting systems at all facilities listed in table 5-6 with higher efficiency lamps, electronic ballasts, and specular reflectors.
- Retrofit lighting systems at the General Mail Facility at San Diego with higher efficiency lamps (32 watt or T-8s) and electronic ballasts. This will require renegotiation of the SES contract, but the savings more than justify this action.
- Replace each electric motor as it burns out with an energy efficient motor.
- Replace all incandescent lamps with compact fluorescent lamps.
- Replace disabled and outdated postal system energy mmanagement and control systems (EMCS) with direct digital control systems in central and large facilities. When properly applied (to HVAC, service water heating and lighting systems), operated and maintained, direct digital EMCS can significantly reduce energy consumption and cost.
- Implement preventive maintenance programs for HVAC to systems to keep equipment operating efficiently and cost-effectively. According to the Division energy coordinator, "About 90 percent of the HVAC system maintenance is performed by outside contractors, and 50 percent of the contractors never show up to perform the maintenance. Enforcement of maintenance contracts has been a major problem because of the lack of staff."

Implementation of most of the lighting-related energy conservation retrofits present annual return on investments greater than 50 percent (see example calculations for one postal facility in table 5-7), with payback period less than 2 years. Two projects have an estimated return on investment of around 300 percent. Other energy conservation measures (e.g.,

Table 5-7—Spring Valley Post Office Lighting Retrofit Analysis

Retrofit savings (kWh)	
Lighting kWh—before	117,543
Lighting kWh—after	43,702
Savings (kWh)	73,841
Percent reduction	63%
Retrofit savings (dollars)	
Savings (kWh)	73,841
Cost/kWh	0.0865
Lighting savings	$6,350.00
A/C savings	$ 952.50
Reduced maintenance	$ 276.00
Total savings/year	$7,578.50
Cost	
Retrofit cost	$18,216 + 3256 (37 additional 2x4)
San Diego Gas & Electric incentive	$11,632
Net cost	$ 9,840
Investment analysis	
Savings—3 years	$22,735.50
Annual return on investment	$ 77%
Payback period (years)	1.3

SOURCE: EMR, "Case Study of Federal Building Energy Use," contractor report prepared for the Office of Technology Assessment, December 1990.

energy efficient motors and EMCS) are also expected to result in payback periods less than 3 years, particularly when current utility incentives are accumulated for calculation of net retrofit costs.

Barriers to Energy Conservation

The Division has been a leader in implementing the first Federal SES contract, and many energy management opportunities still exist. However, there are several barriers to further gains:

- Relatively low priority is being given to energy efficiency improvement because utility expenditures compose a very small percentage of the Division's overall budget.
- Lack of incentives for key personnel to pursue energy conservation. U.S. Postal Headquarters has no incentive programs (e.g., cash awards, recognition certificates, etc.) to recognize employees whose suggestions or actions result in energy and cost savings. The Divisions also do not have any such programs.
- Inadequate support staff to implement energy conservation and preventive maintenance programs for facility and building systems and equipment (HVAC, lighting, etc.).

CASE STUDY 4: FORT BELVOIR ARMY BASE, VA

The Fort Belvoir Army Base consists of 3,000 buildings including housing, a hospital, research and development facilities, administrative facilities, a commissary, cafeterias, warehouses, and hangers. The Base includes a total area of approximately 10 million square feet of buildings. It houses about 2,300 families and has a total daytime population of 16,000.

Current Energy Use

The total annual energy expenditures for the Base are about $14 million. Although a variety of energy sources are used at the Base, electricity and natural gas are most commonly used. Electricity is used for lighting and comfort conditioning. It is also used by computers, security devices, and other electrically driven equipment. Natural gas is used for space heating, cooking, and service water heating.

Energy consumption and cost data for the Base for fiscal years 1980-90 is shown in figure 5-3. Note, energy use at the Base has increased somewhat since 1987 because of factors as described below.

Factors Affecting Energy Use

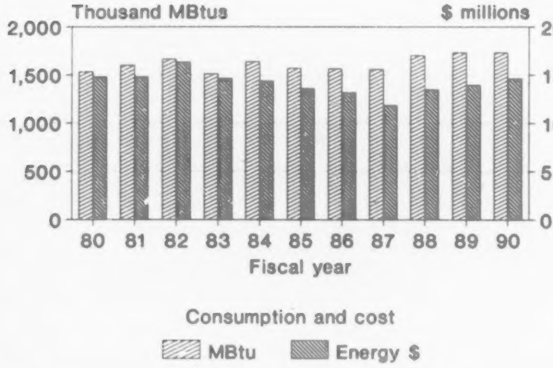
Although the Base has implemented some energy conservation measures, new situations have emerged and resulted in increased energy consumption for comfort conditioning, lighting, and computer equipment. These situations are as follows:

- More building space is being added to the Base. For example, a 230,000-square-foot Army intelligence headquarters recently was built. Additional building space is being planned such as a 3-million-square-foot engineering proving grounds, a 200,000-square-foot industrial park, a 120,000-square-foot commissary, and an 80,000-square-foot warehouse.
- Daytime population at the Base is projected to rise from 16,000 to 30,000 by the year 2000. This includes a large amount of new housing.
- More computer equipment is being used in computer rooms and offices.

Energy Conservation Efforts to Date

The Base has had a formal energy program since 1977 which has implemented many no cost/low cost energy conservation measures. Some significant

Figure 5-3—Fort Belvoir Energy Consumption and Cost, Fiscal Years 1980-90



NOTE: Site accounting used for electricity (1 kWh = 3,412 Btus).

SOURCE: EMR, "Case Study of Federal Building Energy Use," contractor report prepared for OTA, December 1990.

cost measures have also been performed, such as the acquisition of an energy management system. Several capital-intensive measures are currently being studied by the U.S. Army Corps of Engineers, Baltimore District, for selected buildings. Table 5-8 lists those measures which have been partially or fully implemented to date.

Energy Conservation Potential

A significant number of no cost/low cost energy conservation measures have been implemented at the Base. However, they have not been the result of any detailed energy audit of the Base or a comprehensive energy management plan. A study of selected capital-intensive energy conservation measures for specific buildings was under way at the time of this site visit.

Most measures have been implemented on a selected basis. Because of inadequate in-house operation and maintenance staff, many low cost measures have yet to be implemented or need to be repeated.

Maintenance of mechanical systems currently is performed by an outside contractor. However, according to management personnel at the Base, "There is inadequate monitoring of the contractor's performance, and there are not enough incentives for the contractor to do a good job. The contractor basically keeps the systems running, but has no concern for fine-tuning them to conserve energy."

Management personnel at the Base estimate that an additional 20-percent reduction in energy use can be achieved if the following measures are implemented:

- Replace existing ballasts and lamps with higher efficiency electronic ballasts and T-8 32-watt lamps.
- Replace existing energy management system with new system employing direct digital controls. Include optimizing functions on all air handling units and chillers.
- Convert constant air volume systems to variable air volume systems.
- Use adjustable speed drives for variable fan speed control.
- Replace all motors with energy efficient motors.
- Install economizer cycle controls on all air handling units with outdoor air intakes.
- Trim chilled water pump impellers to match load.
- Balance chilled water and air distribution systems.
- Rehabilitate steam plant and eliminate all steam leaks.
- Calibrate all control systems. A well-planned program of control adjustment and calibration should be an important part of any energy management program. It will save energy and money, while also improving comfort conditions.
- Improve maintenance on all HVAC equipment to keep it at peak efficiency.
- Install automated demand limiting controls.

Barriers to Energy Conservation

Despite the past energy conservation efforts at the Base, many barriers still must be overcome in order to achieve further energy and cost savings. These are as follows:

- Lack of staff to develop recommendations for energy conservation retrofits and supportive documentation. According to the Base management personnel, "We have never experienced problems getting funding providing that we have full supportive documentation. However, our staff is so limited that developing ideas and implementing them is a big problem."

Table 5-8—Measures Partially or Fully Implemented to Date at Fort Belvoir

Increase efficiency of heating, ventilating, and air-conditioning systems

Maintain systems for efficiency:

Adjusted air dampers for tight closing.
Adjust fuel-air ratings.
Clean combustion surfaces and strainer screens in pumping systems.
Corrected improper automatic control operation.
Maintained cooling equipment.
Repaired insulation on economizers, condensate receiver tanks, boilers, furnaces, etc.
Repaired leaks: chilled water, condenser water, conditioned air, etc.
Sealed all air leaks into combustion chamber.
Used proper water treatment to reduce fouling of heat transfer surfaces in boilers, heat exchangers, etc.

Operate systems efficiently:

Eliminate or reduce use of HVAC systems which require simultaneous heating and cooling.
Increase indoor temperature and relative humidity levels during cooling season as practical.
Keep air movement in and out of radiators and convectors unrestricted.
Locked thermostats to prevent resetting by unauthorized personnel.
Optimize ventilation startup times.
Reduce cooling in over-cooled spaces.
Reduce fan speed.
Reduce ventilation rates during unoccupied hours to a minimum in noncritical areas.
Turn off cooling system during unoccupied hours in noncritical areas.
Turn off or eliminated all portable electric heaters when not needed.
Use the minimum number of boilers.
Use outdoor air for economizer cooling.
Use spot cooling of people when they were located far apart.

Upgraded equipment to allow efficient operation:

Added automatic draft damper control to reduce heat loss through breaching when the gas or oil burner is not in operation.
Added controls to setback temperatures during unoccupied periods in noncritical areas.
Installed economizer cycle.
Installed automatic ventilation controls.
Installed time clocks on self-contained cooling units for automatic shutoff.
Installed valves and dampers to permit shutoff of heating in unoccupied areas where there is no danger of freezing.
Installed warmup cycle controls on air handling units with outside air intake as applicable.
Installed vestibules and/or revolving doors to reduce infiltration.
Converted constant-volume fan system to variable air volume.[b]
Replaced inefficient window air conditioners.[b]
Isolated off-line boilers.[b]
Installed central supervisory control system.[b]
Installed automatic temperature control valves in radiators controlled by hand valves.[b]
Insulated steam lines, above and below ground.[b]
Insulated chilled water piping and duct work carrying conditioned air through unconditioned spaces.

Improve the building envelope

Added additional insulation to roofs, ceilings and floors over unconditioned areas.[b]
Added additional insulation to walls.[b]
Caulked and weatherstripped windows and door frames.
Installed loading dock door seals.
Lowered indoor temperature and relative humidity.
Reglazed all glass with double glazing.[b]
Reduced solar heat gain.
Repair cracks and openings in exterior surfaces.
Replace broken windows.
Used opaque or translucent insulating materials to block off and thermally seal unused windows.
Used infra-red television camera to determine where heat losses are occurring from buildings and underground distribution piping.[b]

Improve lighting efficiency

Reduce uneeded illumination:

Added switching and timers to turn off lights when not needed.
Moved desks and other work surfaces to a position and orientation that used installed luminaires to their greatest advantage.
Relocated luminaires to provide light on task areas.
Removed unnecessary lamps when those remaining can provide desired illumination.
Use daylighting for illumination in perimeter areas as practical.
Use light colors for walls, floors and ceilings to increase reflectance but avoid specular reflections.

Increase efficiency of lamps, ballasts and fixtures:

Added photocell or time controls to operate outdoor lighting.
Used higher efficiency lamps and ballasts.
Clean lamps, luminaires and interior surfaces.

Miscellaneous

Boost hot water temperature locally.
Improved maintenance of motors.
Installed and maintained insulation on all hot water pipes, fittings and valves passing through unconditioned spaces.
Installed efficient nozzles and faucets and orifices in hot water pipes to reduce flow.
Recover heat from kitchen waste for water heating.
Replaced gas pilots with electric ignition device.
Use demand limiting equipment (e.g., on electric water heaters) during periods of peak electrical demand.
Turn off electrical appliances and machinery not being used.

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[a] Unless otherwise noted, all measures are considered by facility personnel to be low cost or no cost.
[b] Significant cost measure as identified by facility personnel.

SOURCE: Adapted from Enviro-Management & Research, "Case Study of Federal Building Energy Use," contractor report prepared for the Office of Technology Assessment, December 1990.

- Lack of internal incentives to conserve energy, both for operating personnel and the Base as a whole. According to facility personnel, "In the early 1980s, an incentive program was in place whereby the installation that saved the most energy in one year received a proportion of the energy cost savings, which sometimes amounted to as much a $1.5 million." This program was abandoned in 1985.
- Lack of an energy management plan, direction, and guidance from top management. Because operating staff is so limited and the Base is so large, facility personnel need guidance from top management and professional engineering staff to develop and implement cost-effective energy conservation projects.
- Lack of proper maintenance of HVAC systems and equipment. A properly planned and executed program of equipment maintenance can contribute significantly to reduced waste. Equipment which is correctly and regularly serviced and maintained will last longer and will operate more efficiently, thereby requiring relatively less energy than equipment which is ignored. For example, a scale build-up of 1/32-inch on condenser tubes can reduce the efficiency of a chiller by 25 percent, while also cutting down on the effective life of the unit.
- Inadequate contractor incentives based on performance of maintenance on mechanical systems. Under the current contract, the maintenance contractor is provided no incentives such as cash awards for fine-tuning equipment and controls and saving energy. Its main responsibility is just to keep the systems running.
- Shortage of field personnel to inspect equipment and systems and contractor performance. Currently, there is only one quality assurance inspector who performs random inspections and evaluations of contractor performance. More inspectors are needed.

CASE STUDY 5: GSA-LEASED OFFICE BUILDING, WASHINGTON, DC

This privately owned office building is leased by the General Services Administration and occupied by several Federal agencies. Built over two decades ago, the building consists of 88,933 square feet and houses about 750 to 800 daytime employees on weekdays.

Current Energy Use

Several energy sources are used at this GSA-leased building. Electricity is primarily used for space cooling, ventilation, lighting, cooking, and other electrically driven equipment and machinery. Natural gas is used for space and service water heating purposes. Utility bills are paid by the building owner.

According to the building manager, "Overall energy use at the building has slowly increased in recent years, due primarily to increased occupancy and increased use of personal computers." This trend could not be verified because building energy consumption and cost data were not provided by the building owner.

Factors Affecting Energy Use

Although the building has implemented a range of energy conservation measures, the following new situations have resulted in increased energy consumption:

- Personal computers are being used increasingly in the building.
- Occupancy levels have increased approximately 25 percent in recent years.
- New mechanical and electrical equipment has been added to the building to support increased occupancy levels.

Energy Conservation Efforts to Date

Many no cost/low cost measures have been implemented at this building since 1985. Some of these improvements have involved significant cost options such as lighting fixture retrofit. Several capital-intensive measures are currently being studied. Table 5-9 lists those measures which have been partially or fully implemented to date.

Energy Conservation Potential

Because the building has implemented mostly no cost/low cost measures, a significant potential for further energy conservation still exists. Operating personnel estimate that up to a 20-percent reduction in energy use can be achieved if the following measures are implemented:

- Use more efficient ballasts.
- Reduce quantity of service hot water used.

Table 5-9—Energy Conservation Measures Implemented at GSA Leased Building[a]

Increase efficiency of heating, ventilating, and air-conditioning systems

Maintain systems for efficiency:

Adjusted all pumps to control leakage at pump packing glands.
Adjusted outdoor air dampers for tight closure.
Adjust fuel-air ratio and clean filters and combustion surfaces.
Checked flues and chimney for blockages or improper draft conditions.
Clean strainer screens in pumping stations.
Corrected improper automatic control operation and recalibrated controls.
Keep maintenance and operating log of all heating equipment.
Maintain all cooling equipment.
Repaired insulation on economizers, condensate receiver tanks, boilers, furnaces, etc.
Repaired leaks in water, steam, air, fuel distribution system.
Repaired faulty steam traps, valves, dampers, etc.
Sealed air leaks into combustion chamber.
Use proper water treatment to reduce fouling of heat transfer surfaces in boilers, chillers, heat exchangers.

Operate systems efficiently:

Do not cool lobbies, passageways and storage areas to same degree as work areas.
Eliminate or reduce use of HVAC systems which require simultaneous heating and cooling.
Increase indoor temperature and relative humidity during cooling season as practical.
Keep air movement in and out of radiators and convectors unrestricted.
Lower temperature and humidity as practical in heating season.
Locked thermostats to prevent resetting by unauthorized personnel.
Operate heating water and chilled water pumps and cooling tower fans only as necessary .
Operate condenser water system at lower temperature.
Optimize ventilation startup times.
Rebalanced chilled water and air distribution systems.
Reduce ventilation rates during unoccupied hours as practical.
Reduce heating/cooling in over-heated/-cooled spaces.
Turn off cooling system and portable electric heaters during unoccupied hours in noncritical areas.
Use lowest possible radiation temperature in perimeter spaces.
Use the minimum number of boilers and chillers.
Use outdoor air for economizer cooling.
Vary temperature of supply air, chilled water, and heating water and pressure of steam in accordance with load.

Upgraded equipment to allow efficient operation:

Added controls to set back temperatures during unoccupied periods in noncritical areas.
Connected ventilation fans in toilet rooms to light circuit.
Converted constant-volume fan system to variable air volume.
Installed warmup cycle controls on air handling units with outside air intake as applicable.
Installed economizer cycle.
Installed automatic ventilation controls.
Installed valves and dampers to permit shutoff of heating in unoccupied areas where there is no danger of freezing.
Installed automatic temperature control valves in radiators controlled by hand valves.
Installed and maintain insulation on all hot water pipes, fittings and valves passing through unconditioned spaces.
Installed central supervisory control system.
Insulated all duct work carrying conditioned air through unconditioned spaces.
Insulated chilled water piping and ductwork located in unconditioned spaces.
Insulated all steam lines.[b]
Isolated off-line chillers and boilers.[b]
Recovered heat from condenser water system.[b]
Reduced air flow rates to minimally satisfactory levels.[b]
Replaced existing boilers which are not at or near the end of their useful life with modular boilers.[b]
Used low resistance filters, registers and grilles to reduce horsepower required for air movement.[b]

Improve the building envelope

Add additional insulation to roofs, ceilings and floors over unconditioned areas.[b]
Caulked all windows and door frames.
Established rules for building personnel to keep doors and windows closed when possible when heating system is operating.
Installed automatic door closers on all exterior doors.
Repaired cracks and openings in exterior surfaces.
Replace broken windows.

Improve lighting efficiency

Reduce uneeded illumination:

Added photocell or time controls to operate outdoor lighting.
Added manual switches and timers to turn off lights when not needed.
Reduced illumination to levels consistent with productivity, safety and security considerations.
Removed unnecessary lamps when those remaining can provide desired illumination.
Revise cleaning schedule so lights can be turned off earlier.
Use daylighting for illumination in perimeter areas as practical.
Use light colors for walls, floors and ceilings to increase reflectance but avoid specular reflections.

Increase efficiency of lamps, ballasts and fixtures:

Clean lamps, luminaires and interior surfaces.
Used higher efficiency lamps.[b]

Miscellaneous

Avoid using electric water heater during periods of peak electrical demand.
Balanced water flows to minimally satisfactory levels.[b]
Examined elevator usage; shut down excess capacity.
Installed demand limiting equipment.[b]

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[a] Unless otherwise noted, all measures are considered by facility personnel to be low cost or no cost.

[b] Significant cost measure as identified by facility personnel.

SOURCE: Adapted from Enviro-Management & Research, "Case Study of Federal Building Energy Use," contractor report prepared for the Office of Technology Assessment, December 1990.

- Reduce service water heating, generating, and storage temperature levels to the minimum required.
- De-energize hot water circulating pumps when the building is unoccupied.
- Install occupancy sensors, timers, and switches to control lighting.
- Optimize HVAC system controls.
- Use booster heaters for food service. Instead of maintaining the central service water heating temperature at a higher level to satisfy the needs of the food service facility, reduce the temperature of the central systems and add a booster heater at the food service area to elevate water temperature locally.
- Convert constant air volume air handling systems to variable air volume systems.

Barriers to Energy Conservation

Building operating personnel perceive no barriers to their energy conservation efforts. According to the building manager, "The building owner is committed to energy conservation and closely examines energy consumption on a regular basis. Adequate staff is available to keep systems and equipment operating effectively. Furthermore, funding for energy conservation retrofits, training and continuing education is available provided that requests are properly supported with technical documentation and analysis of cost/benefits." However, energy conservation efforts at the facility are largely dependent upon recognition of opportunities by building management and operating personnel. Because further potential for energy conservation still exists at the facility, future energy conservation efforts will depend upon the implementation schedule established by the building manager.

The building is monitored by GSA leasing inspectors who, for the most part, are not engineers. Thus, they cannot offer suggestions and guidance to building operating and maintenance personnel with regards to energy efficiency improvements. At one time, GSA provided a 30-month training program for leasing inspectors, but it was discontinued several years ago.

According to a GSA manager overseeing leasing operations at this building, "Most of the knowledgeable operating staff that GSA had at one time has been hired by private industry. This is because the industry pays them higher salaries and provides better benefits. Current building lease inspectors at GSA are GS-9s, a pay level substantially lower than a person performing the same duties in private industry. This has substantially curbed GSA's efforts to properly monitor leased buildings and to provide suggestions for cost-effective energy improvements."

CASE STUDY 6: RICHMOND REDEVELOPMENT AND HOUSING AUTHORITY, RICHMOND, VA

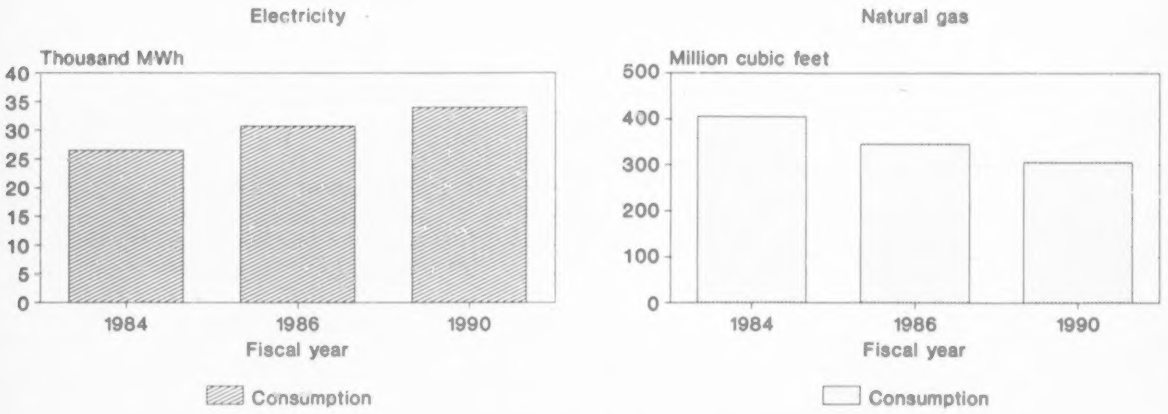
The Richmond Redevelopment and Housing Authority (RRHA) manages 4,500 housing units in 20 different projects. A total of 16,000 residents live in the various projects, many of which were constructed almost half a century ago. All facilities are heated. Only high-rise facilities housing the elderly are provided with air conditioning, using central chilled water systems. Occupants can install their own window air-conditioning units, but they have to pay a monthly usage charge to the Authority.

Current Energy Use

Utility expenses (including water and sewer) constitute 40 percent (approximately $5 million) of the Authority's budget. Several types of energy sources are used at various facilities managed by the Authority. Electricity is used for lighting and electrical equipment in all projects. It also is used in certain projects for electric space and service water heating. In the majority of the projects (4,100 units or 91 percent), natural gas is used for space and service water heating purposes.

Annual energy consumption for all projects at the Authority for selected years is shown in figure 5-4. Although electricity use has increased by about 28 percent since 1984, gas use has decreased by about 25 percent. Despite implementation of various energy conservation measures, electricity use has increased due primarily to increased use of window air-conditioning units by tenants. On the other hand, gas use has declined because of implementation of certain energy efficiency improvements, as well as close monitoring and control by a central EMCS at various projects.

Figure 5-4—Richmond RHA Annual Energy Consumption for Selected Years



SOURCE: EMR, "Case Study of Federal Building Energy Use," contractor report prepared for OTA, December 1990.

Factors Affecting Energy Use

Although the Authority has implemented a range of energy conservation measures, the following new situations have resulted in increased energy consumption for building systems:

- Use of air-conditioning window units by tenants has increased in multifamily projects.
- Authority lacks control over how the tenant uses energy. The Authority does provide guidance to tenants on how to use energy efficiently. However, it has no control over tenants' energy habits (e.g., tenants leaving windows open while HVAC equipment is running or tampering with thermostat set points).

Energy Conservation Efforts to Date

A few energy conservation measures were implemented at various projects as early as 1982. However, most of the energy conservation measures that have been implemented to date were initiated in 1985 when a new general engineer at the Housing and Urban Development (HUD) Richmond field office was assigned responsibility for RRHA. He took personal interest in energy conservation and sought top management commitment in reducing energy consumption and implementing energy conservation measures. His achievements to date include obtaining funding for new computers for use by the Authority to provide more accurate building energy use data and information, and initiating and obtaining funding for a variety of energy conservation projects at the Authority.

A central EMCS has recently been added to monitor and control heating and selected cooling systems in four family projects. RRHA's experience with its EMCS has been very productive. RRHA developed in-house EMCS expertise with an enthusiastic and highly competent staff, leading to innovative use of their system. In addition to providing considerable energy savings, the EMCS' remote monitoring capabilities have helped reduce maintenance service calls.

Many energy conservation measures have been implemented in some, but not all, projects. Several capital-intensive measures are currently being studied. Table 5-10 lists those measures which have been implemented to date at various projects. Implementation of these measures has yielded savings of approximately half a million dollars annually.

Energy Conservation Potential

A significant potential for further energy conservation still exists. According to the engineers at HUD and the Authority, "We have already reduced energy consumption due to various energy conservation actions that we have taken to date. Our ultimate goal is to reduce energy consumption to 55,000 Btu/ft^2, a reduction of over 50 percent."

Table 5-10—Energy Conservation Measures Implemented to Date at Richmond Redevelopment Housing Authority

Replaced doors with steel thermally insulated doors.
Installed insulation in walls.
Installed foam insulation in brick and block units.
Replaced old boilers with high-efficiency condensing boilers having digital controls.
Weatherstripped and caulked all windows and doors.
Replaced all plumbing fixtures with water savings devices.
Installed fluorescent lighting and solid-state ballasts where necessary.
Performed annual preventive maintenance on all heating units.
Performed annual preventive maintenance on all plumbing fixtures.
Added thermostatic controls on the radiators to vary circulating water temperature.
Added central energy monitoring system at four projects to control heating and cooling systems.

SOURCE: EMR, "Case Study of Federal Building Energy Use," contractor report prepared for the Office of Technology Assessment, December 1990.

The Authority intends to achieve further energy reductions by continuing to implement energy conservation measures such as the following:

- Adding insulation to walls in high-rise buildings.
- Installing automatic lighting on/off controls. As example, when automatic lighting controls were installed in a high-rise facility, a 78-percent lighting energy savings was experienced in the facility and payback was in less than a year.
- Installing motion detectors connected to electric baseboard heaters. As example, when the person walks into the room, the heater comes on to maintain 72 °F. When a person walks out of the room, the heater controls set back to 68 °F.
- Expanding the central EMCS (which currently controls 4 of the 20 projects) to monitor and control heating and cooling systems at all projects.

Barriers to Energy Conservation

The following are barriers to energy conservation:

- The 3-year rolling base existing under the Performance Funding System has prevented full implementation of many energy conservation measures. This program was set up by HUD and enacted by Congress. Under this program, HUD provides individual authorities with funding for approved energy conservation projects. Both HUD and the Authority equally share in the savings derived from the implementation of energy conservation measures. At the end of 36 months, the Authority does not receive any share of further savings. Furthermore, the Authority must pay a penalty to HUD if it exceeds the newly established energy consumption levels.
- Lack of incentives for authorities to implement energy conservation programs. In many cases, savings cannot be applied to the facility because of allowable expense level requirements. For example, higher efficiency heating systems are more sophisticated and require more maintenance. Although they result in considerable savings, no allowance is provided for expenses associated with additional maintenance.

Chapter 6

Constraints on Increased Federal Energy Efficiency

(or . . . If there's such great potential, why is it not being captured?)

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Chapter 6

Constraints on Increased Federal Energy Efficiency (or. . . If there's such great potential, why is it not being captured?)

INTRODUCTION

The preceding chapters have suggested that a large fraction of the energy paid for by the Federal Government is wasted. How is that possible? There is no single, simple explanation for all the missed opportunities. There are many reasons, each a constraint to more effective energy efficiency efforts. If left unaddressed, each can inhibit some of the gains which appear technically feasible and economically desirable. OTA identified eight common constraints which can be loosely grouped into three types: 1) constraints on the resources (e.g., funding and personnel) needed to implement energy efficiency measures, 2) a lack of information about the available opportunities, and 3) incentives which do not encourage efficient energy management.[1]

Over the past 15 years, both Congress and the Federal agencies developed several programs which helped ease constraints on increased efficiency in the Federal Government, as described in chapter 2. Implementation efforts have varied over time, however, and general conditions such as the cost of energy and the performance of efficient technologies have also changed. As a result, the constraints on increased efficiency have changed over time, as well. The following sections describe the constraints listed in table 6-1.

RESOURCE CONSTRAINTS

Resource Priorities Favor Other Needs

Energy efficiency projects often receive relatively low priority for funding and personnel, even those with rapid paybacks. Because of the general constraints on funding and manpower that all institutions face (including Federal agencies), this low priority results in foregone opportunities.

Table 6-1—Constraints on Improved Federal Energy Efficiency

Resource constraints

- Priorities favor other agency needs.
  - Energy efficiency is not central to most agencies' missions.
  - Energy is a small component of most agencies' expenditures.
  - Little senior management interest.
- Many measures require initial capital spending.
- Many measures require personnel.
  - Many facilities have no energy coordinator.

Information constraints

- Opportunities have not been systematically assessed.
  - No governmentwide estimates of potential.
  - Little analysis of results of different measures.
- Agencies are uncertain of technical and economic performance.
  - Does this technology really work?
  - Lack of detailed energy use metering.
  - Would the facility be better off waiting for next year's model?
  - Too few demonstration programs.
  - Too little information sharing between agencies.
- Energy-use decisions are dispersed, made by thousands of individuals.
  - Implementation requires coordinated effort from diverse parties.
  - Too little training and education for diverse parties.

Lack of Incentives

- Dollar savings often do not accrue to energy savers.
  - Energy costs are readily passed through budgets.
  - Cost savings are often not retained at facility.
  - Incentives for facility staffs are often indirect.
- Federal procurement policies often favor status quo.
  - Procurement practices are complex, often restrictive.

SOURCE: Office of Technology Assessment, 1991.

An example of low priority can be seen in low attendance rates at the Federal Interagency Energy Policy Committee (the 656 Committee[2]), which is composed of assistant secretaries and assistant administrators of several agencies. As shown in table 6-2, the 656 Committee has had very low turnout of the actual members at its mandatory annual meeting, although lower level substitutes are usually present. Another example of the low priority energy receives can be seen in agency capital budgets dedicated to energy efficiency improve-

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[1] Despite the constraints there are many examples of highly motivated Federal employees who find ways to save energy and money for the government, and take advantage of whatever energy efficiency opportunities they can. See, for example, U.S. Department of Energy, Federal Energy Management Program, "Annual Report to Congress on Federal Government Energy Management and Conservation Programs Fiscal Year 1989," October 1990, App. H. This appendix describes winners of the annual Federal Energy Efficiency Awards for 1990.

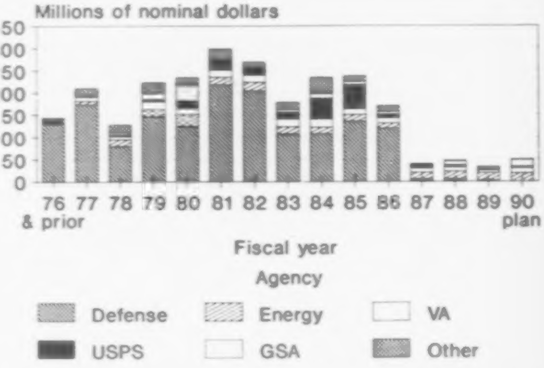
[2] Called the 656 Committee since it is established under Section 656 of the Department of Energy Organization Act of 1977 (see ch. 2).

Table 6-2—Attendance at 656 Committee Meetings

Agency	1988	1989	1990
Department of Energy	A	A	A
Department of Defense Assistant Secretary of Defense (Production & Logistics)	sub	sub	sub
VA Principal Deputy Assistant Secretary Acquisition & Facilities	sub	sub	sub
GSA Commissioner of Public Buildings Service	sub	sub	sub
DOC Assistant Secretary for Administration	sub	sub	sub
HUD Assistant Secretary for Administration	sub	sub	sub
Department of Treasury Assistant Secretary for Administration	sub	sub	sub
USDA Assistant Secretary for Administration	sub	sub	sub
Department of the Interior Assistant Secretary for Policy, Budget & Administration	sub	sub	sub
NASA Assistant Adminstrator for Management	sub	sub	sub
USPS Assistant Postmaster General for Engineering & Technical Support	sub	sub	sub

KEY: A—attended by assistant secretary/administrator; sub—Attended by substitute.
SOURCE: "656 Committee" Meeting Minutes, 1988-1990.

Figure 6-1—Direct Federal Energy Efficiency Funding, Fiscal Years 1976-90



SOURCE: U.S. Department of Energy, Federal Energy Management Program, Report on Federal Government Energy Management and Conservation Programs, Fiscal Years 1987-89; and "Federal Ten-Year Building Plan," DOE-CE-0047, September 1983.

ments over the past decade, as shown in figure 6-1. Notably, the Department of Defense's (DOD's) budget request reached zero for fiscal year 1990 although more funding for 1991 and beyond is planned. A third example of the low priority can be seen in the lapsing in 1985 of the energy conservation goals set forth by the Executive order (see ch. 2). The delay in issuing a follow-on order with revised goals reflected a lack of priority set on energy efficiency in the executive branch.

Two reasons help explain energy efficiency's low priority. **First, with the notable exception of the Department of Energy (DOE), energy efficiency is not fundamental to the mission of most agencies.** For example, the mission of the Department of Veterans Affairs (VA) is to promote the health and well-being of veterans, through such means as the VA hospitals and clinics and through support programs for housing and education. Similarly, the mission of the U.S. Postal Service (USPS) is to deliver mail speedily and accurately. At the Department of Housing and Urban Development (HUD), priorities such as safety- and health-related rehabilitation compete for scarce HUD funds. For example, HUD was directed by the House and Senate Appropriations Committees to reprogram funds in fiscal year 1989 giving a high priority for a lead testing and abatement program.[3] For these agencies and all other agencies, energy is only one required input in performing their mission, and plays only an indirect role.

Secondly, even energy efficiency's indirect role in the mission of most agencies is generally small, reflecting the small amount that energy costs constitute. Reducing energy costs could free up funds for use in better performing an agency's mission. **However, energy typically warrants relatively little time and attention from senior management based on its small contribution to total agency costs** (see figure 6-2). For example, assume that the USPS was able to eliminate energy spending entirely. Even in that extreme and impossible case, the price of a first-class stamp would merely drop from 29 to 28 cents. Labor spending in the USPS far

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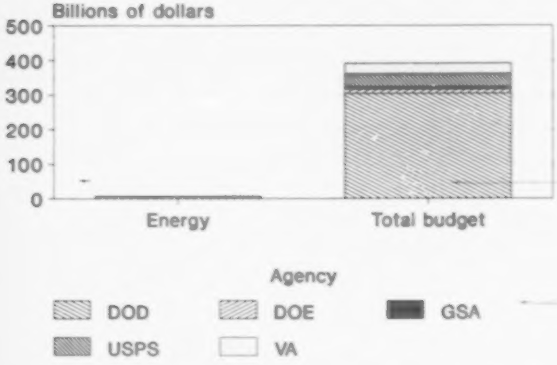
[3] U.S. House of Representatives, *Conference Report to Accompany H.R. 4800*, Report 100-817, 100th Cong., 2d sess., p. 10.

Figure 6-2—Energy Spending Compared to Total Budget for Selected Agencies, Fiscal Year 1989



SOURCE: Federal Energy Management Progam data and fiscal year 1991 Federal budget.

exceeds energy costs, making labor far more important. In fact, reducing postal costs through automation actually increases energy use, as energy and capital substitute for labor.

A new Executive order on Federal energy management signed on April 17, 1991 (see ch. 2) should be an important component of a program to place a higher priority on energy- and cost-saving opportunities throughout the government. Similarly, renewed support at high levels can be seen in a memorandum setting goals and guidance for facility energy management sent by the Deputy Secretary of Defense on March 13, 1991.[4] While an Executive order in itself is not enough to ensure energy efficiency, together with a dedicated implementation campaign, including appropriate budget and staffing requests, it will demonstrate a high priority.

Most Energy Efficiency Options Require Scarce Initial Funding

Most energy- and cost-saving projects such as replacing lamps and fixtures require a commitment of funding, including annual operating and maintenance costs or initial capital costs, or both. However, funding, particularly for initial investment, is typically in short supply.

Many energy efficiency projects have rapid paybacks of 3 years or less, representing a return on investment far greater than the Treasury's cost of funds. Despite these opportunities, Federal agencies have not sought and have not received a stable source of funding for even their most productive energy efficiency projects over the past decade. For example, total capital spending earmarked specifically for energy efficiency projects dropped from a high of $297 million in 1981 to under $50 million in 1990, a decline of 80 percent in nominal dollars, or 90 percent in inflation-adjusted dollars (see figure 6-1).[5]

That trend appears to be reversing partly. For example, DOD's fiscal year 1991 energy efficiency capital investment funding has been raised to $10 million, up from zero in fiscal year 1990 with a target of $50 million annual funding starting in 1993.[6] Similarly, the General Service Administration's (GSA) planned energy investments have increased from $5 million in fiscal year 1989 to $30 million in fiscal year 1991. Just how much capital investment is needed to minimize the Federal Government's long-term energy costs is speculative, but it appears that a return to at least the level of the early 1980s could be productively used.

For assisted households, funding is a similarly large problem (see ch. 3). For example, a 1988 study sponsored by HUD found a backlog of more than $10 billion in safety, health, and efficiency-related maintenance projects in public housing. Against that need, HUD provided public housing authorities with $1.5 billion in fiscal year 1989.

Similarly, the number of low-income households eligible for the Department of Health and Human Service's (HHS) energy assistance program far exceed the availability of funds for weatherization. In fiscal year 1989, about 20 million households met Federal eligibility requirements. However, only 6 million have been weatherized under both DOE's weatherization program and the Low Income Home Energy Assistance Program's (LIHEAP's) weatherization funding even after nearly a decade of those programs. The cost to weatherize the remaining eligible homes can be roughly approximated at $1,500 × 14 million = $20 billion. At current appropriations rates, it would take decades to reach this total. Furthermore, some of the measures performed in weatherization, such as caulking and weatherstripping, have limited (although long) lives and will need to be repeated.

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[4] D.J. Atwood, Deputy Secretary of Defense, U.S. Department of Defense, memorandum to Secretaries of the Military Departments and Directors of Defense Agencies, Mar. 13, 1991.

[5] Note that some energy efficiency projects are often combined with major maintenance, so total efficiency spending is higher than this indicates. For example, when a roof needs repair, adding insulation is often part of the project, although the project is not labeled as an energy efficiency effort. Similarly, when a boiler fails and is replaced, use of a high efficiency unit may be considered normal maintenance and not an efficiency investment.

[6] Millard E. Carr, Office of the Secretary of Defense, personal communication, Dec. 19, 1990.

Shared energy savings (SES) and utility rebate programs are possible private sector supplements to the direct financing of Federal energy efficiency measures.[7] So far, both together have contributed only a small fraction of the direct Federal capital investment in energy efficiency of the early 1980s. Federal agencies are becoming increasingly familiar with the SES approach, but implementation problems remain, and there have been few projects during the past 5 years since authorization by Congress. For example, even DOE still has not had a SES project brought to completion, although several DOE facilities have made attempts. In total, only four projects had been implemented by the end of 1990, representing a small fraction of the 6,000 major Federal facilities.

Where available, utility rebate programs can be a useful supplement to Federal funds.[8] The main obstacle to use of utility rebate programs is the time and availability of agency facility managers to learn about and participate in the programs. Not all utilities have programs, and for those that do, there is a wide range of programs reflecting the capacity and energy needs of the utility.

Virtually All Energy Efficiency Measures Require Personnel

In addition to capital investment, most energy-and cost-saving projects require a commitment of well-trained personnel.[9] Personnel familiar with energy efficiency opportunities are needed at all levels, from the operations and maintenance staff at a facility to the decisionmaking management of the agency. As is the case with funding, personnel are often in short supply.

Some opportunities such as performing regular, high-quality maintenance of heating, ventilation, and air-conditioning (HVAC) equipment cost little more than a careful attention to detail. However, attention to detail is not the default, but rather requires vigilance and follow-through in design of a program and in implementation. As noted in one National Research Council report, "[i]n some Federal facilities, as in some private buildings, systems receive almost no maintenance until something serious goes wrong. In Federal agencies, inadequate maintenance can be traced primarily to tight budgets and unrealistic personnel ceilings."[10]

A related issue is that increasingly over the past decade, maintenance functions in Federal facilities have been delegated to private contractors. In itself, that poses no inherent problem. According to the National Research Council, "most agencies have found that maintenance contractors generally give equal or better service than the government organizations they replace."[11] While that shift reduces the number of Federal operating and maintenance personnel needed, it does not eliminate them. For example, ensuring that private contractors perform high-quality, energy efficient operations and maintenance work on HVAC requires: 1) Federal HVAC experts at facilities to design (e.g., write energy efficient contract clauses), manage, and audit the performance of work;[12 13] and 2) sufficient operating budgets to cover the costs of high-quality work.

Similarly, taking advantage of utility rebate programs for energy efficiency measures also requires sufficient facility personnel to identify projects, negotiate the rebates, follow through on implementation, and monitor results. This is true even for those utility programs which provide engineering and implementation support, although those require less Federal staffing.

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[7] See ch. 2 for a discussion of the shared energy savings and utility rebate programs.

[8] For a discussion of utility rebate programs, see ch. 2.

[9] Building Research Board, National Research Council, *Policies and Criteria for Heating, Ventilating, and Air-Conditioning Systems in Federal Buildings* (Washington, DC: National Academy Press, 1990), pp. 31, 33-35.

[10] Ibid., p. 31

[11] Ibid.

[12] Ronald Smith, "Inspecting Maintenance Contractors," in Federal Construction Council, *Technical Report No. 95: Maintenance of Mechanical Systems in Buildings* (Washington, DC: National Academy Press, 1990), pp. 29-31.

[13] Building Research Board, National Research Council, op. cit., footnote 9, pp. 32-33.

Photo credit: Robin Roy

Despite constraints, many energy efficiency measures have been implemented in Federal facilities over the past 15 years. At the National Records Center at GSA's Suitland Complex, reflective window film both reduced cooling loads and improved occupant comfort.

Many Federal Facilities Have No Energy Coordinator. Among the most important personnel for identifying, implementing, and following through on energy efficiency measures are energy coordinators at individual facilities or in regional offices. As noted in chapter 3, the economic and technical performance of most measures is site-specific. Minimizing the risk while benefiting from available commercial technologies requires a well-trained, competent energy staff to determine which measures are most likely to succeed. This staff expertise is essential given that some poorly performing products are always bound to be available along with the good.

A comprehensive, systematic approach to minimizing energy use and spending requires personnel dedicated to identifying, evaluating, and overseeing the implementation of efficiency projects at each major facility and monitoring performance. Energy management is an area of expertise involving a considerable degree of specialization in such fields as mechanical and electrical engineering and economic and budgetary analysis. Several colleges and professional associations have developed training and certification programs for energy management professionals (see ch. 2) which address these interdisciplinary issues.

Many Federal facilities have no explicit, trained energy coordinator. This is another reflection of the low priority placed on energy. Energy efficiency projects, to the extent they are developed, are often pursued in the spare time of facility staff. Typically, this staff is charged with other critical missions, such as maintaining and operating existing equipment. Often, they have many additional projects which they could pursue depending on priorities, ranging from addressing environmental and safety hazards such as transformers laden with PCBs and asbestos floor tiles to planning for new facilities.

Further reflecting the low priority placed on energy efficiency in recent years, the support for energy coordinators has declined. For example, in a 1989 reorganization, the USPS eliminated its division and regional energy coordinators, rolling those functions into other positions. The energy coordinator positions had been established in 1974, authorizing one energy coordinator for each USPS division and two for each region.[14] Another example of a shortage of Federal energy coordinators is at the Army's Fort Belvoir. That 3,000-building facility has an authorized energy coordinator position, but has had difficulty attracting and retaining candidates. At one point, the position was advertised as available for 18 months before being filled, and one coordinator remained on the job for only 1 year.[15] In part, that may be a result of the relatively low civil service rating offered for this highly technical engineering position. Private-sector energy managers are typically highly compensated engineers, earning over $55,000 annually on average including salary and bonuses according to the Association of Energy Engineers' 1990 salary survey.[16] That exceeds the Federal Government's GS-12 general pay schedule which is common for energy coordinators. In 1990, GS-12 pay ranged from under $36,000 to under $46,571.

INFORMATION CONSTRAINTS

Prospects for Federal Energy Efficiency Have Not Been Systematically Assessed

Information about potential and costs is basic for determining the extent to which additional energy efficiency efforts are worthwhile and for program

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[14] William Eschmann, U.S. Postal Service, personal communication, Sept. 12, 1990 and Jan. 30, 1991.

[15] Patrick McLaughlin, personal communication, U.S. Army, Fort Belvoir, Oct. 24, 1990.

[16] Association of Energy Engineers, "AEE Releases Results of 1990 Salary Survey," Atlanta, GA, 1990.

planning. However, the Federal Energy Management Program has developed estimates of neither the potential energy- and cost-savings nor the capital and other resources required to attain those savings in federally owned facilities. Similarly, none of the individual energy-using Federal agencies contacted by OTA have produced such estimates for their own facilities. The absence of basic, governmentwide information of this type is a serious shortcoming in current Federal energy management efforts.

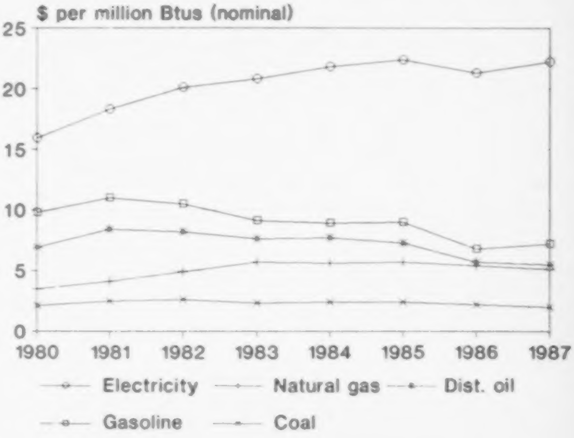
Although building audits mandated under the Energy Conservation Policy Act were conducted at most major facilities in the past decade, the results apparently were neither compiled nor analyzed, much less kept current. The same is true of the facility energy surveys mandated under the Federal Energy Management Improvement Act of 1988.

In contrast to the lack of information for federally owned facilities, HUD has produced estimates of the potential energy- and cost-savings as well as the investment required in HUD-assisted housing.[17] HUD's study provides a basis for internal HUD planning as well as for congressional budget requests.

The information collection and analyses required in developing approximate estimates should not pose too difficult a problem. However, analytically accurate estimates are a moving target; as new energy efficient technologies are developed, facilities are altered and their missions change, and prices of energy go through often surprising gyrations. For example, during the course of OTA's study (July 1990 to April 1991), oil prices shot from $22 per barrel to over $40 then fell below to $20. Any estimates of the economic characteristics of an oil-saving efficiency measure is highly dependent on such price changes. Other energy prices have had less drastic price changes over the past decade, although forecasts have often been inaccurate (see figure 6-3). Notably, electricity, the primary source used in commercial buildings, has had relatively minor cost variations.

The prospect of military base closures creates some uncertainty about the opportunities for long-term energy conservation investments in facilities which may close.[18] For example, an SES project planned for Norton Air Force Base was canceled following proposed closure of the base.[19] In such cases, total prospects for efficiency gains must reflect both rapid payback opportunities and the likelihood of continued facility operation.

Figure 6-3—Historical Energy Price Trends



SOURCE: U.S. Department or Energy, Energy Information Administration, *Household Energy Consumption 1987*, DOE/EIA-0321/1 (87) (Washington, DC: U.S. Government Printing Office, October 1989).

Detailed energy audits of each of the Federal Government's 500,000 buildings and of all operations are not needed for program planning (although audits of major facilities will be needed for comprehensive implementation). While the variety of facilities is great, a survey of a sample of them should serve adequately for program planning and support.

Many Measures Have Uncertain Technical and Economic Performance

Does this technology really work? Would the facility be better off waiting for next year's model, which may have fewer bugs, cost less, and perform better? Since many energy efficiency measures are relatively new and not industry standard practice, these are eminently reasonable questions. Using any new technology entails some risk. No facility engineer wants complaints of inadequate lighting, or of buildings too hot in summer and too cold in winter. Nor do facility staff want to spend money and time unnecessarily on unproductive measures.

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[17] Abt Associates, Inc., "Study of the Modernization Needs of the Public and Indian Housing Stock, National, Regional and Field Office Estimates: Backlog of Modernization Needs," U.S. Department of Housing and Urban Development, HUD-1130-PDR, March 1988.

[18] Millard Carr, U.S. Department of Defense, personal communication, December 1990. Military base closures are conducted under the Defense Authorization Amendments and Base Closure and Realignment Act, Public Law 100-526, Title II, Oct. 24, 1988.

[19] U.S. Department of Energy, "Annual Report to Congress on Federal Government Energy Management and Conservation Programs Fiscal Year 1989," Oct. 3, 1990, p. 28.

There is no lack of technologies which fail to perform as promised. It is likely that there will always be some. Some measures merely provide less energy and cost savings than anticipated, perhaps not justifying the capital and manpower costs for installation. For example, at least two of the Federal facilities in OTA's case studies had energy management and control systems (EMCS) which were largely disabled and clearly not performing as originally expected. The cost savings anticipated when these systems were installed were not being realized. On the other hand, the EMCS at one facility, the Richmond Redevelopment and Housing Authority, is performing better than planned in saving energy, in part due to dedicated and innovative staff effort. In addition, through innovative use of the monitoring capabilities, that system is also providing unexpected benefits such reduced maintenance and repair workloads.

Even when technologies do perform as anticipated, it is often difficult to be sure of that due to the lack of individual metering. For example, a savings of 3 percent in a facility's overall electric bills can be difficult to distinguish from normal month-to-month fluctuations in energy use, leading to doubts about performance. This can be a particularly serious problem given the lack of detailed metering at most facilities. Engineering estimates of savings potential can be used in lieu of detailed, metered data on energy use. However, calibrating engineering models to actual performance is generally very difficult.

Potentially worse than either poor or uncertain economic performance is actual product failure. Some products have failed to perform their basic function, not only wasting installation costs but creating indirect costs as well. For example some of the early electronic ballasts had a high failure rate, burning out soon after installation. The result, for those facility engineers who took the leap into the technology, was a burden on maintenance crews and lighting problems which could interfere with office work. While the current generation of electronic ballasts has proven itself in commercial application, some facility managers have a lingering skepticism and resistance to using them.

Apart from questions of risk in using new products, the question remains of whether future models will perform better and cost less, and if so should equipment replacement be delayed. For example, should a public housing authority undertake a program of early retirement for its oldest and least efficient refrigerators? The best mass-produced models now available use only about half the electricity of older models and may appear cost-effective as early replacements. However, refrigerator efficiencies are expected to increase substantially over the next few years. Under DOE's proposed appliance efficiency standards for 1993, refrigerators will be at least 25 percent more efficient than today's best mass-produced units. If performance really does improve that rapidly (or if costs decline as well), it may be best to continue using an old inefficient refrigerator for another few years before replacing it with an even better model. Choosing the option with the least life-cycle cost requires careful analysis and forecasting of current and future energy prices, and equipment price and performance.

Despite the wealth of diverse experiences with energy management techniques in Federal facilities, there appear to be relatively few formal demonstration programs to help sort out those programs which work from the rest. Different agencies and individual facilities have tried a wide variety of energy efficient measures, providing a potential wealth of information. These experiences could help reduce risk and improve the likelihood of success for further Federal efforts. For example, what were the critical features that allowed the USPS's San Diego Division to successfully complete one of the few SES contracts in the Federal Government, rather than spending months on an unproductive effort? (See ch. 5.) Taking full advantage of the experiences provided by these efforts requires greater information sharing and could also benefit from additional analysis of existing Federal efforts. For example, the quarterly *FEMP Update* is a useful interagency information-sharing forum which could be expanded and made more frequent.

Federal Energy-Use Decisions Are Made by Many Thousands of Individuals With Diverse Perspectives and Responsibilities

Efforts to reduce Federal energy use and spending have to address a wide and diverse group of Federal employees and households receiving Federal energy assistance, a challenging

task. An energy- and cost-saving effort requires coordinating diverse information about engineering, economics, and funding among a wide range of personnel.

Nearly every Federal employee has some input into energy-use decisions. Similarly, the millions of people residing in assisted households have considerable influence over energy use. These individuals decide when to turn on and off lights and office equipment, whether to open windows, and how to set the thermostat. For the vast majority of individuals, their energy-use decisions are small and individually insignificant, mattering only in the aggregate. These employees and households use energy in performing their jobs or in daily residential life. New technologies such as lights controlled by motion detectors in conference rooms and restrooms can further reduce the importance of most individuals' efforts. Often, these Federal employees have little information about the aggregate impact of their individual actions. One example of a dedicated effort to raise energy awareness among all Federal energy users is that of the U.S. Army in Europe. There, innovative information campaigns are coupled with awards and other activities to inform energy users in military housing as well as in offices (see box 6-A).

A far smaller but still large number of Federal employees have jobs more closely related to energy use. There are three main groups:

- facilities engineers and their staffs;
- central and regional office energy offices; and
- field, regional, and central office management.

Typically, facility engineering personnel are responsible for operation and maintenance of one or more buildings. Facility engineering personnel include operation and maintenance staffs, which may include contractors as well as government employees. Efficient operation and maintenance of the main energy uses of lighting and HVAC depended largely on the performance of these personnel. Often, the facility engineering staff is also responsible for devising and implementing some energy efficiency measures, particularly no, low, and moderate cost projects.

All major Federal agencies have an energy office of some type located in the central office or headquarters. Regional offices also may have an energy office. Some individual facilities also have energy coordinators with the explicit function of implementing energy efficiency measures, although that appears not to be the norm. These energy offices have explicit responsibility for disseminating information about energy- and cost-saving opportunities and encouraging implementation of projects. Central and regional office staffs may also have responsibility for approving and prioritizing projects requested by field offices.

Once an energy- and cost-saving project has been identified, decisions about whether or when to fund it may involve many individuals in the agency's management. Often there is a complicated chain of command between the facility engineers and the agency management including facility directors, budgeting and finance departments, policy offices, up through political appointees who determine funding and support for energy projects. This management function requires balancing and trading off between a host of often conflicting demands for scarce resources facing the agency.

Figure 6-4 depicts the decisionmaking steps for implementing energy projects at the Department of Veterans Affairs. Note that line-item congressional approval is necessary for high cost projects (i.e., over $3 million).

Two main challenges are raised by the large number and diversity of parties involved in energy-use decisions. First, for many energy efficiency projects, the activities of the diverse parties need to be carefully coordinated to ensure that project conception, design, budgeting, and implementation all take place. Second, education and training about the opportunities and performance of energy efficiency measures must be diverse, reflecting the diverse information needs and perspectives. For example, boiler operators and mechanics need to be aware of the importance of maintenance programs, as well as the specific mechanical steps required for their boilers. Facility managers and agency management, on the other hand, need not know how boilers and other equipment work. However, to make appropriate manpower and budgeting decisions, they need to be aware of the importance of energy-related maintenance programs in minimizing operating costs of a facility.

Box 6-A—Energy Program of the U.S. Army in Europe[1]

The U.S. Army in Europe (USAREUR) has had an energy program since 1975. With over 25 percent of the Army's personnel stationed across Europe, the energy bill is significant. Thirty-one percent of USAREUR's energy consumption is in mobility operations and the remaining 69 percent in fixed facilities. Through an aggressive energy program USAREUR has reduced its facility energy consumption 46 percent on a Btu/square feet basis since 1975. In dollar terms, this amounts to cumulative cost avoidance of $934 million since 1980.

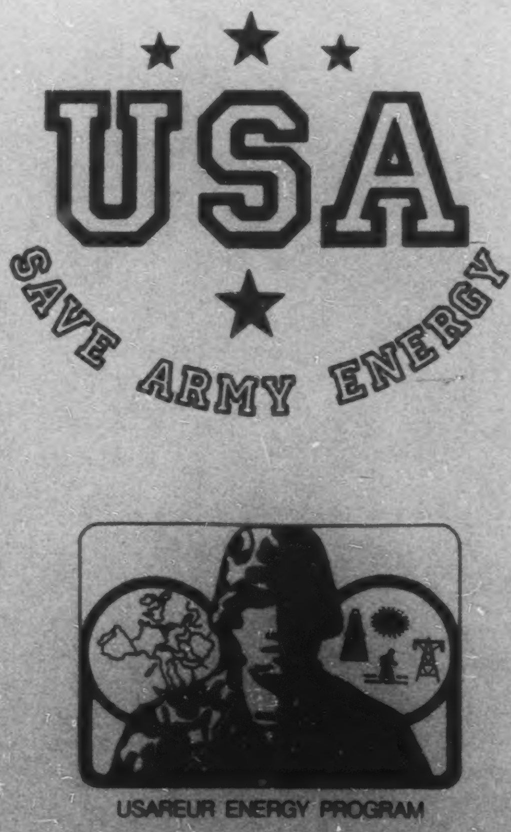
The energy program is comprehensive, establishing an energy chain of command. Goals are set for energy components, such as lighting and heating and cooling; awards are presented; monthly energy letters are widely distributed, and a biannual publication of "Good Ideas," containing all efforts implemented around the communities, is also distributed.

The energy awards program recognizes both small and large communities for saving energy in a variety of categories. The strenuous review of the nominees includes scoring on elements like efficiency measures, short-term measures, long-term plans, numeric performance, mobility fuel savings, special considerations, and a day-long site visit of the finalists. The value of the awards program is multifold. It shows interest and commitment of USAREUR, creates interest and publicity for the energy program, recognizes deserving communities, and reduces energy use. Prior to fiscal year 1991, the recognition included a monetary award, $500,000 for first place and a total of $1.2 million in cash awards to be used on a welfare, morale, and recreation item for the communities' benefits.

The "Good Ideas" energy guide contains measures that were implemented at all levels of the community. Schoolchildren participated in an adopt-a-lightswitch program, one community sponsored an energy rapper contest to involve young soldiers, numerous communities implemented retrofits on their lighting system, and at Heidelburg the batallion has 1 hour of mandatory energy training monthly. In all there were over 400 ideas implemented by the engineering department, the community, and the command.

The energy program in USAREUR is a model to be replicated throughout the armed services. During congressional hearings in the summer of 1990, Jeffrey Jones, Director for Energy Policy, stated:

> In 1989, the Deputy Secretary of Defense requested that the Defense components take a closer look at such incentives and suggested that the concept be applied Department-wide. Unfortunately this coincided with a reduction in operations and maintenance funds which would be used to provide such incentives. We are currently reviewing the Department's overall conservation program and the methods for instituting tangible incentive programs.[2]



Raising awareness of energy use is one facet of the comprehensive energy conservation program for the U.S. Army—Europe.

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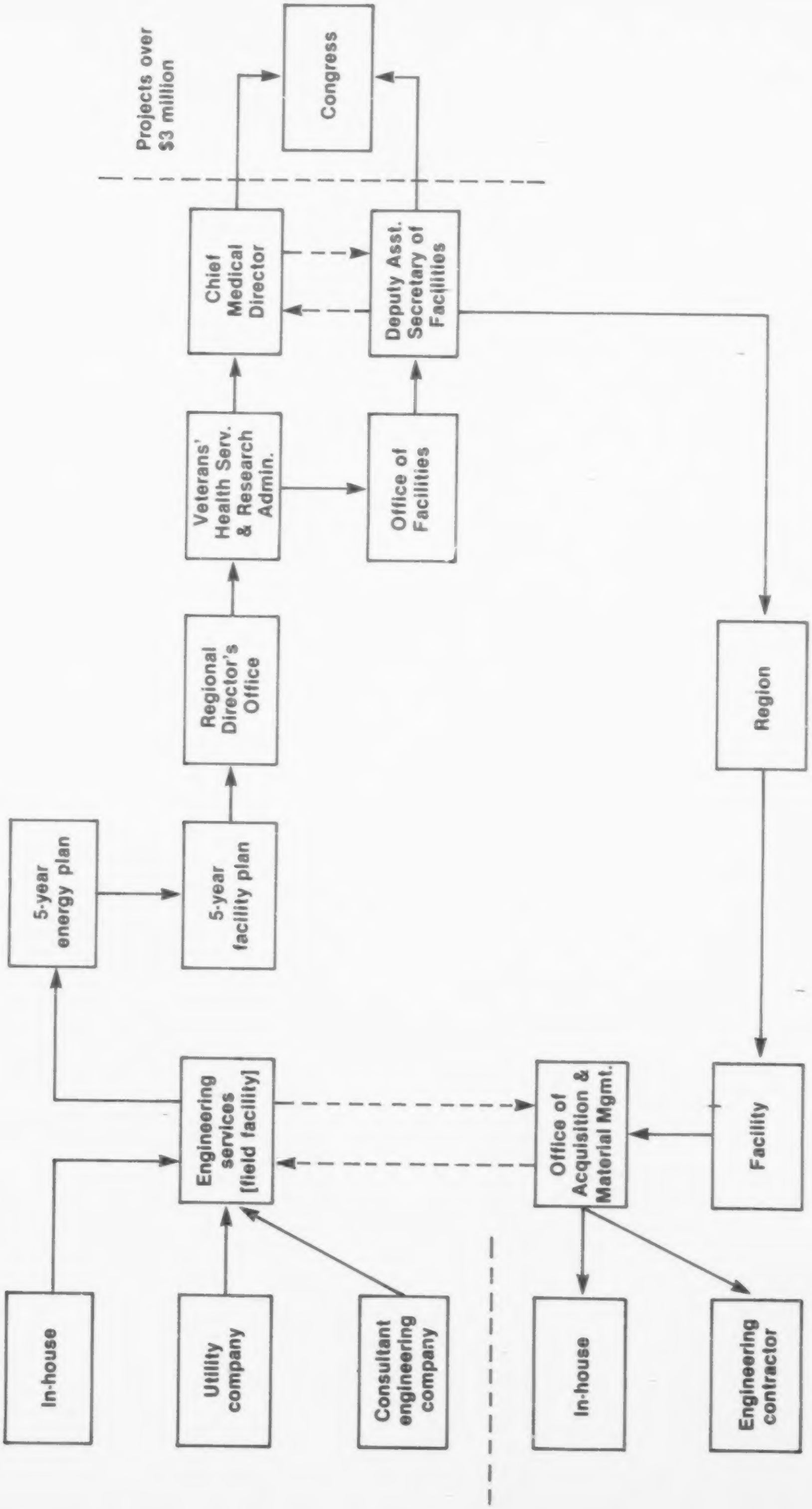
[1] Information based on Col. Robert Fear, U.S. Army, letter to OTA and attachments, Dec. 5, 1990.

[2] Jeffrey A. Jones, Director for Energy Policy, Office of Secretary of Defense, testimony at joint hearing on Federal Energy Use in Federal Facilities, before the House Subcommittee on Energy and Power of the Committee on Energy and Commerce and the House Subcommittee on Environment, Energy and Natural Resources of the Committee on Government Operations, July 11, 1990, p. 5.

Figure 6-4—Simplified VA Energy Investment Decision Process


In-house
Utility company
Consultant engineering company
Engineering services (field facility)
5-year energy plan
5-year facility plan
Regional Director's Office
Veterans' Health Serv. & Research Admin.
Office of Facilities
Chief Medical Director
Deputy Asst. Secretary of Facilities
Projects over $3 million
Congress
Region
Facility
Office of Acquisition & Material Mgmt.
In-house
Engineering contractor

SOURCE: OTA, 1991, adapted from Charles Likel, U.S. Department of Veteran's Affairs, letter to Helene Kirwan-Taylor on Energy Conservation Projects, OTA, October 1990.

LACK OF INCENTIVES

There Have Been Few Rewards for Efficiency and Penalties for Waste

Incentives can either reward desired behavior or penalize undesired behavior. Neither carrots nor sticks have been widely and systematically used in the Federal Government to promote energy efficiency. There are notable exceptions, but generally, facility managers have neither rewarded nor penalized staffs for their energy efficiency performance; regional and headquarters offices neither rewarded nor penalized facilities; and Congress neither rewarded nor penalized agencies.

What happens if an individual facility does not pursue efficient measures for energy and cost savings? Usually, not much. Energy budgets are generally based on previous years' expenditures. That is necessary since, with existing information, it is difficult for budget analysts in an agency's headquarters to know whether energy use and spending is wasteful (see "Prospects for Federal Energy Efficiency Have Not Been Systematically Assessed," above). Even if energy bills increase dramatically, central offices often have little choice but to allow the additional funds given their lack of detailed information. Dramatic but apparently reasonable increases in spending do occur. For example, the Washington, DC, VA Hospital had a more than fivefold increase in spending on purchased steam in the late 1980s. This increase resulted from a new pricing and accounting method used by the neighboring hospital, seller of the steam.[20] While entirely unanticipated, the VA had no real choice but to provide additional needed funds to the facility. Determining whether the new higher prices justify substantial improvements in the efficiency of the VA Hospital's steam use is largely beyond the resources of the central office staff. Again, the lack of detailed central office attention reflects the understandably low priority of energy efficiency. A penalty, particularly one which is misapplied, is likely to restrict a facility's ability to perform its basic mission, an intolerable outcome.

Many agencies' headquarters or regional energy offices set targets for energy use at facilities to promote the long-term, energy-reduction goal required by the Federal Energy Management Improvement Act (see ch. 2). But again, since there is no systematic auditing of facilities' spending on energy nor the opportunities for savings, these goals are somewhat arbitrary and not backed up by penalties. Similarly, when the 20-percent reduction goal from Executive Order 12003 lapsed unmet in 1985, there were no apparent penalties.

What are the penalties if an agency overall does not pursue efficient measures? The answer is much the same as for the individual facility. Congressional committees have neither the information nor the time to determine in detail the specific wasteful uses of energy by Federal agencies, and are not likely to tolerate restricting a agency's ability to perform its basic mission.

What are the rewards for agencies and personnel that aggressively attain energy- and cost-savings? The National Defense Authorization Act for fiscal year 1991 allowing military base commanders to retain two-thirds of the savings generated from shared energy savings programs are a notable example of an explicit, direct incentive (see ch. 2). The U.S. Army in Europe has had a several-year effort to create energy conservation incentives for the military families housed there (see box 6-A). Another example is the monetary incentive program developed by the National Capital Region of the General Services Administration for its facility personnel (see box 6-B).[21]

More typical, however, has been a lack of direct incentives. Utility accounts are separate items in facility budgets: any savings in utility spending is realized by the regional or central office rather than the facility manager. Similarly, field personnel (e.g., boiler operators and maintenance crews) do not typically receive awards based on energy savings. There may be some indirect incentive at all levels expressed through performance reviews and promotion opportunities. For example, minimizing energy costs is one way a facility manager can meet overall budget goals, which may be part of the incentive

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[20] Mark Butcher, Assistant Chief of Engineering, Washington VA Hospital, personal communication, Sept. 19, 1990.

[21] The GSA award program is one part of an intensive campaign which includes access to funding for efficiency measures and training and education about new energy efficient products.

Box 6-B—General Services Administration Memorandum Sent to All District and Buildings Managers in the National Capital Region

Fiscal Year 89 Energy Efficiency Awards

Continued efforts to save energy in Federal buildings is a top priority for the Buildings Management Division (BMD) in fiscal year 1989 and through 1995 in order to meet the 10-percent energy reduction goal, as mandated by the Federal Energy Management Improvement Act of 1988.

As in fiscal year 1988, BMD will recognize accomplishments of increased energy conservation for fiscal year 1989 through the Energy Efficiency Award Program to the field offices which demonstrate the greatest progress in conserving energy. Similar to last year, a field office must conserve at least 2 percent in energy consumption, over the previous year, to be considered for the award.

For the fiscal year 1989 awards, cost savings of at least $1 million, by the Region, will warrant a 5 percent distribution to the winning field offices. Therefore, the maximum cash disbursement for the region would be $50,000. A minimum savings of $200,000 is required in order for the Region to provide Energy Efficiency Awards, with a cash disbursement of $10,000 to the winning field offices.

Hopefully, this will challenge each and every manager to achieve as much energy savings as possible and partake in the $50,000 maximum disbursement for this fiscal year.

SOURCE: Jack E. Babcock, Director, Buildings Management Division, General Services Administration National Capital Region, memorandum to District and Building Managers on Fiscal Year 89 Energy Efficiency Awards, Mar. 30, 1989.

package. These incentives, while potentially valuable, are indirect and diluted.

Procurement Policies Are Challenging[22]

Federal procurement policies are often cumbersome and confusing when applied to energy efficiency measures.[23] Difficulties of identifying novel energy-efficient products and services are a built-in disincentive to change. The Federal Government procures a great variety of energy-related goods and services, and procurement policies are correspondingly diverse. For example, procurement policy determines how gas and electric utility service is obtained, whether and how facilities contract out their HVAC system operating and maintenance services, which commonly used items such as lamps and refrigerators are available through the Federal Supply System, and what economic analysis methods are used to trade off long-term savings against initial costs for a new refrigeration unit.

Two main challenges are raised by procurement policy. **First, for some commonly used items available through Federal Supply System, there is little information comparing their life-cycle energy and economic characteristics.** For example, the GSA-authorized contract schedules for emergency exit signs do not give a clear, unbiased assessment of the performance and savings to be expected when using light-emitting diode signs instead of standard incandescent signs, both of which are available.[24] Similarly, facility engineers are given little information about the performance of lamps, which are supplied by DOD's Defense Logistics Agency. In contrast, GSA's Household Appliances Schedule, which includes products such as refrigerators, water heaters, and room air conditioners, lists only the lowest life-cycle cost items.

Often, the only information on product performance is that provided by the vendors. A purchaser must be previously aware of the opportunities for energy savings, and be willing to dedicate time and effort to learning about the alternative products. In absence of awareness, time, and effort, purchasers may be expected to continue to use standard replacement products. **This challenge is particularly important since the supply system includes many inefficient products.**

Second, Federal procurement methods are complex, potentially resulting in a cumbersome or confusing process which can impede use of novel goods and service contracts. Federal procurement is naturally complex, reflecting the diverse goals of the process. While the foremost goals are "economy, efficiency and effectiveness," also included are socioeconomic development (e.g., for small, disadvantaged businesses),[25] and efforts to promote competition and to protect against fraud and abuse. Together with the diversity of products and services noted above, the result is a complex system. The small number of Federal SES contracts to date is one example of contracting difficulties raised by procurement policies. As noted in chapter 2, SES has been slow to develop in part due to the challenge of developing an acceptable contract and due to the lack of service companies willing to respond to complex Federal proposals.

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[22] See ch. 2 for an overview of procurement.

[23] At least, that is how it is described by many of the Federal workers with whom OTA staff met.

[24] See box 3-A in ch. 3 on exit signs.

Complex procurement policies may even have hindered Federal facilities from participating in utility rebate and incentive programs which encourage use of high efficiency equipment and methods (see ch. 2). While Federal acquisition regulations appear to include no specific prohibitions against participation in such utility programs, there are no specific allowances either to accept what might be construed as a gift. To clarify that Federal participation in utility programs is indeed legal and in the national interest, in 1990 Congress specifically included language to that effect for GSA[26] and DOD.[27]

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[25] See 48 CFR 19 (Oct. 1, 1983).

[26] Treasury, Postal Service and General Appropriations Act, 1991, Public Law 101-509, Sec. 15.

[27] National Defense Authorization Act for FY 1991 (NDAA), Public Law 101-510, Sec. 2851.

Chapter 7

Policy Issues and Options for Improving Federal Energy Efficiency

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Chapter 7

Policy Issues and Options for Improving Federal Energy Efficiency

Despite the wide array of programs which have been developed over the past 15 years, the Federal Government still has many opportunities to improve energy efficiency in its facilities and operations using commercially available, cost-effective measures. Just as there is no single constraint explaining the failure to harness many opportunities, there is no single, simple policy that will ensure the greatest use of energy efficiency measures in the Federal Government. Fortunately, none of the constraints are fundamental obstacles; rather, all can be addressed by a variety of new and existing initiatives. In fact, many new initiatives may involve simply making widespread use of the best practices already found in some Federal facilities and operations today. Still, taking full advantage of existing opportunities will require a higher priority for energy efficiency as reflected in adequate investment funding and staffing.

This chapter first summarizes the variety of benefits that improved Federal energy efficiency could bring to the government and to the Nation as a whole. The second part describes a range of policy options which Congress could consider for enhancing current efforts if it views the benefits of improving Federal energy efficiency as worth pursuing more completely.

CONGRESSIONAL INTERESTS IN FEDERAL ENERGY EFFICIENCY

There are good reasons for Congress' continuing interest in Federal energy efficiency. The potential benefits of improved efficiency include:

1. demonstrating energy efficient measures useful throughout the economy, not just in the Federal Government;
2. supporting markets for suppliers of efficient products and services;
3. learning firsthand which approaches work as a basis for national policy (e.g., while the Federal Government is not entirely analogous to the private sector, many of the constraints on Federal energy efficiency and their solutions may pertain to the private sector);
4. reducing Federal spending without reducing services; and
5. reducing energy-related environmental and security problems.

While the benefits of improved Federal energy efficiency can be great, there are costs as well. The effort involved can be considerable, in particular requiring initial capital investment and staffing and the attention of Congress and senior executive branch personnel.

Demonstrating Efficient Measures Useful in the Private Sector

Federal demonstration can be an effective tool for promoting energy efficiency in the private sector. The Federal Government has broad experience using electricity, natural gas, petroleum products, and other energy sources in housing, office buildings, hospitals, transport, and other facilities and operations. From lighting to heating, ventilation and air-conditioning (HVAC) equipment to automobiles, the Federal Government has an opportunity to set a good example for energy efficiency while demonstrating the use of a wide range of measures. By demonstrating the cost and performance of energy efficient technologies and operating strategies in its own facilities and operations, the Federal Government could help reduce the risk and uncertainty that private-sector managers perceive when considering these measures for their own facilities. This demonstration should encourage greater private-sector adoption, as noted by several respondents to one survey on Department of Energy (DOE) conservation research and development (R&D) programs.[1]

Supporting Markets for Suppliers of Efficient Products and Services

A second way that Federal use of efficient goods and services can spill over into the private sector is by accelerating development of more efficient products by manufacturers. By virtue of being such a large consumer of energy-using goods and services, the Federal Government helps define the market which manufacturers aim to serve. For example, about 1 percent of new domestic automobiles and light trucks are purchased by the Federal Government. Similarly, around 10 percent of residential appliances are used in federally assisted or owned households (although nearly all are purchased privately, not by the government). By supporting the use of the most cost-effective energy efficient products, Federal purchasing power can promote earlier introduction of high efficiency technologies. Some utilities are working on a similar approach (sometimes called the "golden carrot"), which would be aided by Federal procurement. For example, Pacific Gas & Electric Co. and other utilities will offer $300 rebates for refrigerators which exceed the National Appliance Energy Conservation Act standards for 1993 by at least 25 percent. The aim is to "accelerate introduction of such refrigerators by several years."[2]

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[1] The Alliance to Save Energy, "The Department of Energy's Conservation R&D Programs: Results of a Survey of Industry Leaders," Washington, DC, March 1989, pp. 5, 7, 9-11.

Providing a Firsthand Basis for National Energy Policy

There is a clear government interest in promoting energy efficiency throughout the economy reflected in a wide range of both legislation and executive agency activities (e.g., DOE's Office of Conservation and Renewable Energy). Federal experiences with in-house energy management can provide useful policy insights into energy efficiency policies for the private sector since many of the constraints on Federal energy efficiency also apply in the private sector. For example, many private-sector institutions have funding and staffing constraints which effect their energy efficiency prospects. Similarly, a lack of information on the technical and economic performance of energy efficiency measures exists in the private sector as well as in the Federal Government. While the Federal Government is not completely analogous to the private sector, Federal experiences may be useful in developing broader national energy efficiency policies.

Reducing Federal Spending

There is a clear Federal interest in ensuring that government services are performed efficiently to minimize spending. Many energy efficiency measures are available which, if employed, would reduce the cost of government. There are no comprehensive analyses of the potential for savings, but as described in chapter 3, highly cost-effective opportunities in federally owned facilities could total on the order of at least $1 billion annually. These total potential savings dwarf in comparison with the total Federal spending (which for fiscal year 1989 was $1.1 trillion), but are a larger fraction of discretionary spending (about $300 billion)[3] and of the deficit (about $160 billion in fiscal year 1989).[4] While not a panacea for eliminating the Federal deficit, energy efficiency measures can produce considerable savings while requiring no reductions in government programs. Also, many measures are well-understood and relatively risk-free methods of reducing spending.

On the negative side, most energy- and cost-saving measures require an investment of capital or personnel. Although for many efficiency measures, cost savings within the first 3 years (and in some cases, within the first year) more than recover any initial investment, funding and personnel resources are essential. These resources are typically scarce in Federal agencies. The return on investment of many measures is excellent, far higher than the Treasury's cost of funds, but that does not ensure availability of Federal funding. Besides requiring initial funding and personnel, pursuing fuller implementation of efficiency measures requires the time and attention of agency management, which is also typically scarce.

Reducing Energy-Related Environmental, Health, and Security Costs

In addition to the direct economic savings, increased energy efficiency has indirect environmental, health, and security benefits. This is true of federally purchased energy as well as energy used in the private sector. Energy production and use are leading factors in many environmental issues facing the Nation such as urban ozone, acid rain, and potential climate change.[5] Similarly, energy production and use are contributors to some health problems ranging from respiratory disease related to particulates and sulfur oxides[6] to still speculative concerns such as the biological effects of electric and magnetic fields.[7] While the actual health and welfare costs to society are not fully understood for these environmental impacts, Congress devotes considerable effort to addressing them. Dependence on foreign fuels also raises concerns about energy security which may have profound policy implications.[8] Increased Federal energy efficiency and the spillover into improved private-sector efficiency can help reduce these indirect costs.[9]

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[2] Letter from Mason Willrich, Pacific Gas & Electric Enterprises, Mar. 25, 1991.

[3] U.S. Bureau of the Census, *Statistical Abstract of the United States: 1990*, 110th ed. (Washington, DC: 1990), table 502. This includes outlays which can be increased or decreased by Presidential decisions, and require no change in existing Federal laws. For example, this list does not include Social Security, Medicare, and prior year contracts and obligations.

[4] Ibid., table 497. Includes off-budget receipts, outlays, and transactions as defined by Office of Management and Budget.

POLICY OPTIONS

Ongoing support for existing Federal programs is essential in promoting Federal energy efficiency. These programs provide the framework for future energy-and cost-savings efforts, even though today they are not implemented thoroughly. The current level of support may be sufficient to maintain the framework but is inadequate for realizing the full potential of cost-effective, energy-saving measures and for setting an example for supporting private-sector efforts.

There are several options Congress could consider if it views improved Federal energy efficiency as worth pursuing more vigorously (see table 7-1). All could help improve Federal energy efficiency. Some measures, such as revising procurement policies and creating monetary incentives for agency personnel, require modest or negligible initial costs. However, realizing the full potential will require the investment of funds and staffing.

Table 7-1—Policy Options for Federal Energy Efficiency

- ***Maintaining the status quo***
- ***Dedicating resources***
  - Increasing funds for investment
  - Supporting an adequate staff
- ***Encouraging agency efforts***
  - Setting standards for performance
  - Rewarding agencies and individuals for energy and cost savings
  - Revising procurement: information, life-cycle costing, and simplification
  - Following through and enforcing
- ***Promoting research, development, and demonstration***

SOURCE: Office of Technology Assessment, 1991.

Maintaining the Status Quo: Present Trends in Federal Energy Management

Over the past 16 years, Congress and the executive branch have developed a wide range of programs promoting energy efficiency within the Federal Government, as described in chapter 2. These programs have been effective to some degree, helping to save a total of about $7 billion (about 5 percent of Federal energy spending) in Federal buildings and operations between 1975 and 1989.[10] However, implementation efforts for Federal energy management waned during the 1980s, as indicated by an 80-percent drop in capital investment for conservation measures between fiscal year 1981 and 1989. (Adjusting for inflation, $300 million in 1981 would be over $450 million in 1991 dollars.) That declining trend has reversed beginning in fiscal year 1990, although funding levels are still low. In fiscal year 1990, funding has increased slightly to about $50 million, which is still far less than the $300 million invested in 1981. For fiscal year 1991, DOD and GSA alone have increased planned energy efficiency investments to $40 million.

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[5] See, for example, U.S. Congress, Office of Technology Assessment, *Catching Our Breath: Next Steps for Reducing Urban Ozone*, OTA-O-412 (Washington, DC: U.S. Government Printing Office, June 1989); and U.S. Congress, Office of Technology Assessment, *Changing by Degrees: Steps To Reduce Greenhouse Gases*, OTA-O-482 (Washington, DC: U.S. Government Printing Office, February 1991).

[6] See U.S. Environmental Protection Agency, Office of Air and Radiation, "Regulatory Impact Analysis on the National Ambient Air Quality Standards for Sulfur Oxides (Sulfur Dioxide)," draft, May 1987, ch. 6 and 7.

[7] For example, see U.S. Congress, Office of Technology Assessment, *Biological Effects of Power Frequency Electric and Magnetic Fields—Background Paper*, OTA-BP-E-53 (Washington, DC: U.S. Government Printing Office, May 1989).

[8] See U.S. Congress, Office of Technology Assessment, *Oil Replacement Capability*, forthcoming, 1991.

[9] For example, as part of a pollution prevention strategy to reduce emissions of SO_2, the Clean Air Act Amendments of 1990 specifically encourages utilities to use conservation and renewable energy. Public Law 101-549, Title IV, Section 404F, Nov. 15, 1990.

[10] In addition to Federal programs, an overall improvement in the efficiency of appliances and equipment being manufactured today contributes to Federal energy savings. For example, even an average new refrigerator or air conditioner is far more efficient than the average 15-year-old model it replaces.

In addition to funds for capital investment, funding for interagency coordination, training, information sharing, and analysis of governmentwide opportunities has been increased by over two-thirds in fiscal year 1991 to $3 million. These activities, which are performed by the Federal Energy Management Program (FEMP), are useful for improving Federal energy efficiency at as low a cost as possible (see ch. 2). The higher level of funding is intended to support increased governmentwide coordination and analysis. OTA did not analyze how effectively FEMP uses its current funding for interagency coordination and analysis of, and support for, governmentwide opportunities. Therefore, it intends no suggestion as to whether the FEMP budget would benefit from further increases, or whether less important activities could be cut back, or whether useful activities could be absorbed within the existing budget by simply increasing managerial efficiency.

Current Federal efforts together with a general improvement in the efficiency of HVAC and lighting equipment on the market should help to gradually improve Federal energy efficiency. However, the improvements will be far smaller than is economically attractive. For example, there are probably a few billion dollars worth of highly cost-effective energy efficiency investment opportunities (e.g., with returns on investment of 25 percent or more) in federally owned buildings alone, and another few billion dollars worth in federally assisted housing (see ch. 3). At the current low level of energy efficiency funding and staffing for individual agencies, it would take several decades to make all the economically attractive investments. During that time, tens of billions of dollars would be unnecessarily spent to buy inefficiently used energy.

Dedicating Funds and Staff

Increasing Funds for Investment

Funding for conservation investments is essential for many energy- and cost-saving opportunities. **There are several billion dollars worth of highly cost-effective energy-efficiency investment opportunities in federally owned and assisted buildings**, as noted above. Many of these measures have very high returns on investment, several times higher than the Treasury's cost of funds. For example, an investment replacing existing low-efficiency magnetic ballasts and fluorescent tubes with high-efficiency tubes and perhaps electronic ballasts may produce an annual return on investment of 30 percent or more (one utility-assisted lighting retrofit at the U.S. Postal Service San Diego Division has an annual return on investment of over 380 percent). (See ch. 2.) In comparison, the Treasury's current cost of funds is nominally about 6 to 8 percent.[11] Thus, if new Treasury obligations were used to fund efficiency investments, savings in energy costs could greatly exceed interest on the new debt.

Precisely how much additional investment would be productive and over what timeframe? It appears **that an increase in Federal investment at least to the level of the early 1980s, during which a few hundred million dollars were available annually, could produce very high returns for the foreseeable future.** Even greater funding may also be useful, although Federal agencies have not comprehensively assessed the extent of existing opportunities, and the precise amount is uncertain (see ch. 3). As one step to ensuring appropriate funding, **FEMP could be required to provide estimates of the governmentwide potential energy and cost savings and the capital investment required to attain those savings in its annual report to Congress.**

The source of energy investment funds and the best way to administer them are critical issues. As an alternative to having each agency obtain its investment funds through its budget requests and appropriations, **Congress could consider establishing a governmentwide revolving fund for Federal energy efficiency projects.** The LoanSTAR program in the State of Texas provides one example of how such a governmental energy efficiency fund can work (see box 7-A). Based on the high returns on investment for many efficiency measures, a fund based on new Treasury obligations could be entirely self-supporting. As another alternative, a fund could be raised by placing a surcharge on energy spending in federally owned buildings. For example, a surcharge of under 3 percent would generate a $100 million fund in 1 year.

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[11] As of Feb. 20, 1991, 30-day Treasury bills have a nominal interest rate of about 6 percent; 30-year Treasury bonds currently yield about 8 percent.

Box 7-A—The Texas LoanSTAR Program: A $98-Million Conservation Fund for Government Buildings[1]

The Texas LoanSTAR program is a $98.6-million, 8-year, statewide energy conservation program established in 1988. It offers loans of up to 4 years in length to public-sector institutions in Texas, including State agencies, local governments, universities, and schools. Initial capital for the program came from oil overcharge funds.

To secure a loan, a building is first given an energy audit to identify potential retrofit projects. Projects compete for funds on the following criteria: estimated payback, ability to repay the loan through energy savings, engineering assessment of the project, and the feasibility of effectively metering the project. The maximum loan for a State agency or university is $4.8 million, while the maximum for a local government or school district is $1.2 million. Repayments are made semiannually at a 4.04-percent interest rate.

A monitoring and analysis program (MAP) is a central component of LoanSTAR. Monitoring and analysis of energy usage patterns helps identify changes in operation and maintenance that may result in substantial savings. Also, MAP compares the actual savings of completed retrofits to the estimated savings to help program managers determine which measures to weed out so that unsuccessful ones will not be repeated elsewhere.

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[1] Texas Governor's Energy Management Center, "Texas State Energy Conservation Plan and Energy Extension Service Combined Grant Application," June 1990, pp. 72-91; and Malcolm Verdict et al., "Monitoring $98 Million in Energy Efficient Retrofits, the Texas LoanSTAR Program," paper presented at the American Council for an Energy-Efficient Economy 1990 Summer Study on Energy Efficiency in Buildings, Asilomar, CA, Aug. 26-Sept. 1, 1990.

Supporting an Adequate Staff

Adequate funding alone is not enough to produce the greatest energy and cost savings for the Federal Government. **It is at least as important to have a trained, competent, and motivated staff at individual Federal facilities, and in central and regional offices, dedicated to successful implementation of energy saving measures.** Minimizing risks while benefiting from commercial or forthcoming technologies requires a well-trained, competent energy staff including engineers to determine which measures are most likely to succeed. Staff expertise is essential given that the applicability of many measures is site-specific and that some poorly performing products are always bound to be available along with the good.

Many energy efficiency opportunities require qualified facility personnel but not Federal investment funds. For example, a program such as shared energy savings (SES) contracting (see ch. 2) which relies on private-sector funds requires staff with expertise in energy-related engineering, finance, economics, and contracting, not Federal funds for investment. Similarly, participation in utility programs, even those which provide technical and implementation assistance, requires the dedicated attention of facility personnel familiar with the facility's needs and opportunities. As another example, efficient operation and maintenance of HVAC equipment requires professional, trained technicians (whether Federal employees or through contractors), not capital investment.

Agencywide or governmentwide support programs can also effectively supplement special or occasional needs of facility personnel. For example, the technical expertise provided by the mobil energy laboratories (MELs) sponsored by FEMP (see ch. 2) can work with facility personnel to identify energy efficiency measures, perform technical and economic analyses, and assist with implementation. Similarly, the facility energy surveys performed by the Army Corps of Engineers and the efficiency programs developed by the Naval Facilities Engineering Command are but two examples of important regional and central office supplements to the efforts of personnel at individual facilities. These, too, require adequate staffing. For example, there are only four MELs, a small number considering the thousands of Federal facilities.

As one step to ensuring that appropriate staffing is receiving adequate priority at individual agencies, **Congress could require the agencies, the Office of Personnel Management, and FEMP to report on agency staffing issues in FEMP's annual report on Federal energy management.** This discussion could include basic information on the qualifications and number of energy-related staff (particularly energy coordinators at facilities), an analysis of the adequacy of current staffing to the broad range of efficiency programs currently being pursued, and an analysis of the ability to recruit and retain staff that considers factors such as pay differentials between the private sector and the Federal Government.

DOE's experience in applying energy efficiency measures outside the Federal Government could also supplement agency efforts. For example, DOE's Institutional Conservation Program has assisted energy efficiency efforts in public and nonprofit hospitals and schools for over a decade. Some of the lessons learned by headquarters and field office personnel could be useful in implementing energy efficiency programs in Federal hospitals and schools.

Encouraging Agency Efforts

Setting Standards for Performance

Some existing standards for energy efficiency could be expanded. Federal agencies currently face at least four standards for energy efficiency (these are described in ch. 2). One standard is the use of life-cycle costs in designing new Federal buildings and in comparing investments in alternative building systems, described in the previous section. A second standard is a mandatory design criterion for new Federal buildings. This state-of-the-art standard was developed over the past decade by DOE, the American Society of Heating, Refrigerating and Air-Conditioning Engineers, and the Illumination Engineering Society.

Third, nationwide standards specifying minimum efficiencies for household appliances and ballasts indirectly benefit Federal facilities as they purchase new equipment, just as national standards for automobile efficiency effect the Federal fleet. New national standards, for example for lamps, could be considered which would indirectly result in further efficiency improvements at Federal facilities.

Similarly, the Federal vehicle fleet is required to meet the corporate average fleet economy (CAFE) standard. Currently, the Federal fleet outperforms that standard by 7 percent. Still, Congress could consider strengthening the Federal fleet standard to require outperforming the CAFE requirement by a larger amount.

A fourth standard facing Federal agencies for their existing buildings is a requirement that energy consumption be reduced by 10 percent by 1995 relative to 1985.[12] That requirement, enacted by Congress in 1988, filled the void left when the energy-saving goals set forth in Executive Order 12003 lapsed in 1985. Extending this requirement beyond 1995 together with a new minimum savings target could help promote greater continuity in Federal energy efforts. Also, the standard could be expanded to include energy used in operations. This type of standard based on a percentage reduction goal is relatively simple to understand and to keep track of, making it a useful tool.[13] A key issue is the appropriate targets to set.

The Executive Order signed on April 17, 1991 sets a reduction target for Federal buildings of 20 percent by the year 2000 relative to 1985. It also specifies a target of reducing 10 percent of the gasoline and diesel fuel used in certain Federal passenger vehicle and light truck fleets. These targets provide valuable guidance to the agencies. However, they are not based on an analysis of existing opportunities and could potentially be strengthened. Congress could direct DOE to perform a life-cycle cost analysis of energy efficiency opportunities for a sample of Federal facilities and operations as a basis for setting a target.[14] The number of facilities surveyed and the acceptable level of detail and accuracy need to be balanced against the cost and time required.

Revising Procurement: Information, Life-Cycle Costing, and Simplification

Some Federal procurement policies could be revised to encourage greater use of energy efficient products and services. One possible procurement change is to improve information on energy-using goods provided to agencies through the Federal Supply Schedule and Supply Catalog programs managed by GSA and the Defense Logistics Agency (see ch. 2). Currently the supply schedules and the GSA Supply Catalog provide little or no information on the energy efficiency of products provided. This is true even for energy-intensive products such as light bulbs and ballasts. Federal purchasers must obtain contractors' catalogs and price lists for information, but even these may contain inadequate or incomplete information on energy characteristics. To be effective, the information would have to be in a form useful to facility personnel. It may include information on both life-cycle costs and on efficiency or performance.

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[12] This type of standard is not unique to the Federal Government. For example, New York's Executive Order 132, signed Jan. 2, 1990, directs State agencies to reduce energy consumption in both buildings and operations by 20 percent in the year 2000 relative to 1990.

[13] There are some complications even with this simple standard. For example, how should variations in energy use due to fluctuations in weather or occupancy levels be addressed?

[14] The target should specify whether source accounting or site accounting is used for electricity since the choice can make a difference (see ch. 2).

A second possible procurement change is to increase the use of life-cycle costing in the selection of goods and services. Currently, agencies are directed to consider life-cycle costs in their purchases of certain products such as HVAC equipment, and GSA considers life-cycle costs in selecting household appliances such as refrigerators and water heaters. This practice could be expanded to include more energy-using goods such as lamps, ballasts, and automobiles, and by performing more frequent updates of analyses for household appliances. Energy-related services could be included too. For example, the selection of contractors for operation and maintenance of HVAC equipment at Federal facilities could be based on life-cycle costs including not only the direct cost of the contract, but also the expected cost of energy used based on the practices specified in the contract.

A third possible procurement change is to simplify procurement of new energy efficient products and services. Some Federal procurement policies are complex, cumbersome, or confusing, which can impede use of novel goods and services. This is particularly important since many energy efficiency measures are relatively new. One example of a confusing situation which seems to have been resolved is the ability of Federal facilities to accept utility rebates. Because procurement policies had not previously addressed that situation, there was some question about whether and how Federal facilities could receive rebates for performing energy management activities. To clarify the issue, the National Defense Authorization Act for fiscal year 1991 (NDAA, 1991) and the Treasury, Postal Service and General Appropriations Act, 1991, explicitly allow DOD and GSA to participate in utility programs. Similarly, the New Item Introductory Schedules seem to be a useful mechanism for simplifying and speeding the availability of novel products in Federal facilities. There may be other areas where a change or clarification of acquisition regulations could help promote energy efficiency measures. For example, changing the regulations governing SES contracts to simplify them and increase agency flexibility may help promote that novel form of private financing. Also, the "Operations and Maintenance Energy Services" contract developed by the Navy to simplify and speed up contracting for some high payback projects could be analyzed for use throughout the government.[15]

Rewarding Agencies and Facilities for Energy and Cost Savings

Because energy is not central to most agencies' mission, and because energy costs are such a small component of most agencies total spending, energy efficiency naturally receives a relatively low priority. **Creating incentives for agencies and individual facilities is one way to raise priorities for energy efficiency efforts.** There are notable exceptions, but generally Congress has neither rewarded nor penalized agencies for energy-related performance; regional and headquarters offices neither rewarded nor penalized facilities; and facility managers neither rewarded nor penalized their staff.

Under NDAA, 1991, military facilities are now allowed to retain two-thirds of the energy cost savings (see ch. 2). That type of incentive could be expanded by offering it to all agencies, not just Department of Defense (DOD) facilities. DOD's new incentive needs to be carefully monitored to ensure that it is being properly and fully implemented, and revised as necessary.

Rewarding Individuals for Energy and Cost Savings

At least two existing types of incentives for individuals could be considered for greater use.[16] **First, FEMP's annual Federal Efficiency Energy Awards (see ch. 2) could be expanded by giving award winners not just a certificate of merit, but a cash bonus as well.**[17] Often, the FEMP award winners have demonstrated not just innovation in energy management, but also produce tangible cost-savings which far exceed their salaries. A prize of several hundred to a few thousand dollars for each of the 15 award winners each year could be an effective part of a campaign to increase awareness and enthusiasm for FEMP's important activities, as well as reward excellence in public service. The cost of the prizes should be more than compensated for by reduced spending on energy, although the savings accrue to the agencies, not to FEMP.

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[15] See U.S. Department of Energy, Federal Energy Management Program, "Federal Energy Management Activities," DOE/CE-0281-1, winter 1990, p. 4.

[16] Performance awards and superior accomplishment awards are explicitly allowed under 5CFR 430 and 5CFR 451 (Jan. 1, 1991 edition).

[17] GSA currently gives Federal Energy Efficiency Award winners a $1,000 bonus as part of an incentive program.

To reach out to all of the several thousand Federal facilities (not just the handful receiving FEMP awards) would require a more broad-based incentive. One model which could be considered is the monetary incentive program developed by the National Capital Region of the General Services Administration (GSA) for its facility personnel (see ch. 6). **DOE and GSA could analyze the National Capital Region's innovative incentive program to determine how to best replicate it throughout Federal facilities.** Key issues include which personnel should be eligible for awards, the methods used to demonstrate that energy and cost savings actually occur, and the amount of the bonuses.

Following Through and Enforcing

Following through on Federal energy management programs is essential. Ongoing congressional attention in the form of new legislation, hearings and other contact helps raise the priority of energy efficiency efforts within Federal agencies. The same is true of the many General Accounting Office reports requested by Congress on Federal energy efficiency efforts.[18] To demonstrate further interest, Congress could consider requesting regular or occasional reports by inspectors general at the five key energy-using agencies which together account for over 90 percent of Federal energy use and have most responsibility for Federal energy management.[19]

Promoting Research, Development, and Demonstration

Research, development, and demonstration are all vital to innovation and the practical application of new energy efficient technologies. For example, highly efficient electronic ballasts which are now commercially available were partly a result of Federal R&D efforts at Lawrence Berkeley Laboratory.[20] Vacuum insulation, expected to become commercially available in applications such as highly efficient refrigerators later in this decade, is another technology benefiting from Federal R&D. R&D in physical sciences and engineering is essential for making this type of hardware available.

Commercialization and widespread application do not necessarily result rapidly after development of even economically attractive technologies. Again, the long time between research, commercial production, and eventual widespread use for modern electronic ballasts provides an example. Close cooperation between research and development and the manufacturers is critical to ensuring that useful new concepts proceed toward commercialization as rapidly as possible.

Even for economically attractive new commercial products, gaining consumer acceptance and widespread use takes considerable time. Under what conditions of initial cost, future savings, and risk will consumers and institutions adopt new energy efficient technologies? Research into these perspectives can be useful in developing programs which best deliver energy- and cost-saving technologies both for the Federal Government and for the private sector. Similarly, there can be substantial benefits to demonstrating how well and under what conditions energy efficient measures work in the real world. Making the most effective use of Federal funds involves a balance between this type of R&D and the type in physical sciences and engineering.

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[18] General Accounting Office reports on Federal energy efficiency efforts reach back at least to the late 1970s. See, for example, U.S. Congress, General Accounting Office, *Evaluation of the Plan To Conserve Energy in Federal Buildings Through Retrofit Programs*, EMD-78-2 (Washington, DC: Mar. 29, 1977); and U.S. Congress, General Accounting Office, *More Use Should Be Made of Energy-Saving Products in Federal Buildings*, EMD-79-10 (Washington, DC: Jan. 23, 1979).

[19] Among the purposes, Congress specified in establishing the offices of inspector general is "to provide leadership . . . and recommend policies . . . to promote economy, efficiency, and effectiveness" in Federal agencies. Inspector General Act of 1978, as amended Public Law 95-452.

[20] M.A. Brown, L.G. Berry, and R.K. Goel, *Commercializing Government-Sponsored Innovations: Twelve Successful Buildings Case Studies*, ORNL/CON-275 (Oak Ridge, TN: Oak Ridge National Laboratories, January 1989), pp. 34-42.

One aid to demonstration would be to produce and disseminate written analyses of the major energy efficiency measures taken at Federal facilities (for example, those winning FEMP awards). These reports could describe the type of measures taken, the costs involved, staffing requirements, a comparison between estimated and actual savings of both energy and spending, and the name of someone to contact for further information. These reports could be compiled and published regularly as one part of FEMP's interagency coordination and information sharing activities. Eventually, there would be no need to report on some measures as they become widely accepted with well-understood costs and performance.

Another valuable demonstration would be to identify, implement and monitor *all* measures meeting minimum cost-effectiveness criteria at several selected facilities of different sizes and uses. These measures should include lighting, HVAC operations, maintenance and retrofits, and upgrades of miscellaneous equipment (e.g., refrigerators). In general, performing the most cost-effective measures first appears to be a reasonable practice (as long as that doesn't preclude later retrofits). However, using several facilities as showcases or models of the entire range of measures could help demonstrate the Federal government's full cost-effective potential and the feasibility of different approaches. One example of this type of demonstration is an effort by the Pacific Northwest Laboratory and FEMP to develop a model for use by Federal customers of the Niagara-Mohawk Power Corp.[21]

Finally, basing Federal procurement of energy-using products on life-cycle costs can play a role both in encouraging development and in demonstration without increasing spending on R&D. (See "Supporting Markets for Suppliers of Efficient Products and Services," above.)

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[21] Pacific Northwest Laboratory, "Proposed Federal Agency Energy Efficiency Model Program with Niagara Mohawk Customers," undated.

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